ARTICLE III.

THE CLASSIFICATION OF THE OPHIDIA.

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Owing to the absence of limbs and other points in which diversity is usually apparent, the classification of the snakes has always presented difficulties to the zoölogist. An order which dates from Cretaceous time and has spread over the entire world, must have differentiated in structure, if its history has been like that of other orders of Vertebrata. Yet the researches of anatomists have only resulted in finding characters which define five suborders, and about a dozen families. Of the natural groups thus defined, one family, the Colubridæ, embraces three-fourths of the species, and is of cosmopolitan distribution. So long as this was the principal result attained, it remained clear that the stronghold of the order had not yet been taken.

The primary divisions above referred to are defined by peculiarities of the skeleton, and these were mostly originally described by Johannes Müller. In the preparation of their Herpetologie Générale, Duméril and Bibron made a full study of the dentition. The results they obtained were important, but they were very far from expressing an exact and clear-cut classification. The greatest defect of their definitions based on the teeth is that they too often fail to define. One type passes by easy gradations into another, so that in many cases it is impossible to determine what type a given dentition represents. In most cases it is clear that, among Colubrid snakes at least, no higher groups than genera can be predicated on dentition, and frequently not even these. Under such circumstances further structural characters had to be sought for if we are to have any clear idea of the affinities and phylogeny of this curious branch of the Reptilia. In any case, no systematic arrangement can be regarded as final until the entire anatomy is known.

In 1864* I pointed out that certain snakes, notably the water snakes, have the

* *Proceedings Academy of Natural Sciences,* Philada.

vertebral hypapophyses continued to the tail, as in the truly venomous forms. Boulenger has since found this character in a good many forms which I had not examined and which have no affinity to the water snakes. This character, while important, presents the same evanescent stages in certain types that the dental characters before noticed exhibit. It had long appeared to me that the only prehensile organs possessed by serpents, the hemipenes, might probably present structural variations expressive of affinity or diversity. In 1893 * I examined these structures in many of the leading types and was gratified by the discovery of a great many structural characters. In fact these organs exhibit a variety of ornamentation and armature beyond any part of the anatomy in the Ophidia, and I am satisfied that they furnish more important indication of near affinity than any other part of these reptiles yet examined. No one hereafter can be sure of the place of a serpent in the system until the hemipenis has been examined.

Still another part of the structure remained to be studied. The assymmetry of the lungs of snakes had often been noted by anatomists, but very little was known as to the range of variation. Accordingly, when I undertook † a study of the pulmonary organs, I was able to confirm observations previously made by Schlegel and Stannius, and to correct some others, and to add a great number of facts as to species not previously examined. I give the details observed in the following pages. One result is that I am able to confirm the conclusion of Boulenger, *i. e.*, that the Colubriform venomous snakes, the Proteroglypha (cobras, Elapes, etc.), do not differ in any fundamental respect from the non-venomous Colubridæ, aud that they cannot be characterized as a suborder. The suborders then are:

Catodonta (Type Glauconia).
Epanodonta (Type Typhlops).
Tortricina (Ilysiidæ and Rhinophidæ).
Colubroidea (Peropoda, Asinea, Proteroglypha and Platycerca).
Solenoglypha (Typical venomous forms).

I. THE HEMIPENIS.

The hemipenis is a projectile organ in the form of a hollow tube whose base is on one side of the middle line and which opens into the anus. When retracted it lies beneath the tail, extending for a greater or less distance, and terminating in a cylindrical muscle. This has considerable length and is finally inserted on a caudal vertebra. When the organ is projected this muscle is drawn forwards so as to evaginate the

* *American Naturalist*, 1893, p. 477 ; 1894, p. 831.

† *Proc. Amer. Philos. Soc.*, 1894, p. 217.

tubular organ. Thus the inside of the tube becomes the outside, and the entire organ projects freely from its base anteriorly. It finds its way into the corresponding oviduct of the female, and when once in place it cannot be retracted in most species without invagination. This is performed by the contraction of the now internal retractor muscle. This is inserted on the internal face of the apex, and draws it inwards, so that it soon assumes the original ensheathed position beneath the tail. It cannot be withdrawn from the oviduct without invagination, because it is generally set with strong bony spines which diverge backwards. They have a perfect grip on the walls of the oviduct and would, in some instances, lacerate that organ if the two bodies should be forcibly drawn apart. In other cases the hemipenis would be torn off at the base. Snakes sometimes partially project this organ, apparently in some instances for defense, as the spines are very pungent and are sometimes curved like cats' claws. Snakes are, however, very careful not to present these organs fully evaginated so as to expose the delicate structures near the apex. I have never seen this to be the case in an alcoholic specimen (with one possible exception), and I should judge that this was the general experience, from the figures given by authors.

The hemipenis of the Ophidia is traversed by a groove which divides the superficial investment to the internal integument (or external integument when the organ is retracted), which commences at the base internally and soon turns to the external side of the organ and continues to its extremity. This is the sulcus spermaticus (s s in Pl. XXVII). This sulcus is always bifurcated in venomous snakes, and I find it to be equally bifurcated in many harmless snakes (Figs. 2, 3, 7). The investing tissues may or may not correspond with this bifurcation. Thus the hemipenis may be more or less bifurcate (Figs. 1, 2, 7, 9, 10, 11). Schlegel states that it is bifurcate in venomous snakes, but it is not so in the sea snakes *Hydrophis* and *Hydrus*, nor in *Bungarus semifasciatus*, *Hoplocephalus coronatus*, etc., while it is bifurcate in many non-venomous forms. Next to the bifurcation of the sulcus in importance is the nature of the surface of the external investment (internal when retracted). In the most perfect types, both venomous and non-venomous, this surface is reticulate like tripe, the enclosed areas forming calyces, which may have a suctorial function (Figs. 6, 9, 10, 11). Their borders are often papillose, and are sometimes so deeply divided into papillæ as to lose their original character. These papillæ may be the seat of osseous deposit, becoming bristles or spines (sp), which become larger towards the middle of the length and lose their mutual membranous connections. These isolated spines may extend to the apex, but they rarely extend to the base. The surface may, however, be laminate and not reticulate, and the laminæ may be longitudinal (Figs. 4, 7) or transverse (Figs. 1, 2, 3, 5). In either of these cases they may not be spiniferous. The

apex or apices of the organ may be furnished with a rigid papilla (Fig. 5) or awn, or a membranous disc.

In the Tortricina and Peropoda (the constrictors) the hemipenis is not spinous and the sulcus is bifurcate (Figs. 1, 2, 3), and in the Boidæ the hemipenis is bifurcate also, although in some genera (Xiphosoma, Ungualia) the branches are very short. The external integument is never reticulate, but is always laminate with elongate papillæ at the extremities, in Epicrates (Fig. 2), and Xiphosoma. The laminæ are pinnate from the sulcus as an axis in Morelia, Boa, Eunectes, Enygrus, Lichanura and Eryx, and are transverse (flounced) in Charina (Fig. 3). In Ilysia they are pinnate (Fig. 1), with a few longitudinal plicæ below. In the Colubroidea the majority of genera are calyculate and spinous. Nevertheless, the Calamarinæ are smooth or papillose, and certain Tropical American forms are disciferous instead of calyculate. Some are spinous to the tip. Among these, the Natricinæ have the spines minute, but their weakness is offset by the presence of a few large hooks at the base of the organ. The sulcus is either simple or bifurcate in the Colubroidea.

Gradations in the characters of the hemipenis similar to those found in the Colubroidea are to be seen in the types of venomous snakes. Thus in the Proteroglypha this organ is spinous to the tip, on a calyculate basis, in Hydrophis, Hydrus and Elaps. It is reticulate at the extremities and spinous below in Dendraspis, Adeniophis (*bivirgatus*), Naja (Fig. 9), Acanthophis, Bungarus and Sepedon, the apex with a smooth apex in the genus first named.

In Solenoglypha, in the genus Atractaspis, the apex is calyculate plicate and the remainder is spinous on a longitudinally laminate basis. In Causus the calyculate structure is well developed. In the Viperidæ and Crotalidæ the spines are on a flounced basis. The apices are calyculate in Bitis, Clotho (Fig. 10) and Vipera, and spinous in Cerastes. They are calyculate in Crotalidæ in Bothrops, Ancistrodon, Crotalophorus and Crotalus (Fig. 11).

The spines are not ossified in young snakes, and some may retain their flexible condition to half-grown dimensions. The calyces are also tenuous and lacking in papillæ in young individuals. Hence it is important that adults be selected for examination. It is useless to expect to find the organs projected in any number of alcoholic specimens; and when projected, the terminal portion is not everted, but the spinous portion only is exhibited. This part of the organ is apparently used sometimes for defense. I have also found that females are two or three times as abundant in collections as males, a fact which would indicate that they are more easily captured. I have failed, up to this writing, to secure males of a number of genera of which I have access to females, which accounts for their omission from this paper.

In examining the structure of the hemipenis the organ must be laid bare *in situ* and split lengthwise along the exposed (inferior) middle line before it is removed. This is necessary to avoid cutting it along the sulcus, which extends along the side.

II. THE PULMONARY STRUCTURES.

The condition of knowledge as to the lungs of snakes was stated by Stannius, in 1856, as follows: "The detailed accounts as to the single or double character of the lungs leaves much to be desired. Among Ophidia Angiostomata there possess a single sack, Rhinophis and all Typhlopidæ which have been examined; as to the Tortricidæ [Ilysiidæ] there are apparently species with two lungs (*T. xenopeltis*) [= *Xenopeltis unicolor*] and others with a single lung (*T. scytale*) [= *Ilysia scytale*]. Among Eurystomata, all the Peropoda (Boa, Python, Eryx) possess apparently two lungs, The Calamarina that have been investigated have one lung. Among Colubrina and Glyphodonta there are great variations. All the Coronellæ of Schlegel possess, according to Schlegel, a single lung. I find the lung single in *Rhachiodon scaber* [*Dasypeltis*]. *Tropidonotus natrix* [*Natrix vulgaris*] has a very small rudiment of a second lung. *Coluber* [*Spilotes*] *variabilis* possesses, according to Schlegel, the rudiment of a second lung. According to the statement of Meckel, this rudiment is common in Coluber. The Xenodons have, according to Schlegel, a single lung (*X. severus* and *X. rhabdocephalus*). In Heterodon I find a rudimental second lung. The Lycodons, according to Schlegel, possess a single lung, as also do Psammophis and Homalopsis. In *Dendrophis colubrina* Schlegel found the rudiment of the second lung. In Dipsas, according to Schlegel, there are variations; but he states that *D. multimaculata*, *D. lævis* and *D. annulata* [*Sibon annulatum*] have but one lung. The Achrochordina have but one lung. Among Hydrophidæ I found in three species of Hydrophis the lung-sack simple. Meckel states that Platurus has a very small rudiment of a second lung. Among the remaining poisonous snakes there is an insignificant rudiment of the second lung in the Elapina and Crotalina, while the Viperina possess an entirely simple lung." *

An examination of about one hundred and fifty species of nearly all types yielded the following results:

The snakes with rudimental posterior limbs (Peropoda) show in the character of their lungs what they show in the rudimental limbs themselves and in the hemipenis, the nearest relationships to the Lacertilia. They possess, with an exception to be noted later, two well-developed lungs, one of which is larger than the other. The

* Stannius, *Zootomie der Amphibien*, p. 108.

smaller lung lies to the right side and ventrally, while the larger one lies to the left side and dorsally. In some species the dorsal and ventral relation is more pronounced than in others. In the Colubroidea the right or ventral lung is generally present, but of very much reduced proportions, the usual size being from two to five millimetres in length. It is connected with the other lung by a foramen which perforates the tracheal cartilage at a point a little beyond the apex of the heart and opposite to the proximal part of the dorsal lung. It is sometimes connected to the dorsal lung by a short tube, in which cartilaginous half rings are seen in but two of the genera examined, viz., Heterodon and Conophis. The lumen of the rudimental lung may be lined by the same reticulate structure as is seen in the dorsal lung, or its walls may be smooth. In some Colubroidea the rudimental lung is absent, but such species are relatively few.

The dorsal lung may present proximally alongside of the trachea an auricle or pocket, and this is so developed in the genus Heterodon as to reach to the head without communication with the trachea other than that furnished by the normal portion of the lung. In the Solenoglypha, without exception, this extension of the dorsal lung is present, and extends to the head, and its lumen is continuous with the trachea throughout its length. The same structure exists in the genera Hydrus and Hydrophis, and also in the West Indian peropodous genus Ungualia, which differs besides from other Peropoda in having but one posttracheal lung. Finally the tracheal lung, as I have called it, is distinct from the true lung in the water snakes Platurus and in Chersydrus. In the former of these genera the trachea is not separate from the lumen, while in Chersydrus it is distinct. It, however, communicates with the cells of which the lung consists in this genus by a series of regularly placed foramina on each side. There is no lumen in the tracheal lung of Chersydrus. In the blind burrowing Typhlops we have a still further modification of the tracheal lung. It is without lumen, and is composed of coarse cells of different sizes. These have no communication with the trachea or lung that I can discover. It has occurred to me that this structure, which extends from the heart to the throat, may not be a pulmonary organ.

I have referred to the dorsal and ventral positions of the two lungs. The rudimental lung is to the right of the dorsal lung in the Colubroidea, but in the Ilysiidæ it is to the left. It is quite questionable which lung this rudiment in this family really represents. In the Typhlopidæ the single lung is on the right side and extends from the heart to the liver. It has the position of the rudimental lung of the Colubroidea and may represent it. I cannot decide this question without further material. In Glauconia there is but one true lung, and this is ventral in position and originates

to the right of the heart, so that in this genus also it may represent the rudimental lung of the Colubroidea. There is here no tracheal lung or organ.

The rudimental lung is often concealed from view and difficult to discover. The best test of its presence is the foramen which connects it with the trachea, which will generally be found piercing the cartilage of the latter near the apex of the heart. The rudimental organ may then be found by inserting a bristle and observing its destination through the more or less transparent tissues. In but one instance have I found a rudimental lung without a connecting foramen, viz., in the Mexican *Ficimia olivacea*. On the other hand, the foramen may terminate in a small blind sac.

The pulmonary characters may be determined without much dissection. The position of the heart must be first ascertained and a longitudinal median incision made in the abdominal wall. In all forms except the Epanodonta and Catodonta the trachea will be found passing to the left side of the heart and entering the lung near its apex. By splitting the trachea, not too near its abdominal border, on turning the free margin upwards as the snake lies on its back, the *foramen bronchiale* will be seen and its lumen can be explored. The trachea is concealed by the œsophagus, which must be drawn to the left side of the body in order to make the examination. The examination of the tracheal lung requires the division of the abdominal wall further towards the head.

The tracheal lung greatly extends the surface available for blood aëration. This is useful to snakes for the reason that the huge masses of food which they ingest so compress the true lung that another organ is necessary. Most snakes, whether they have a tracheal lung or not, have the pulmonary organ greatly elongated, so that while one portion is compressed by the contents of the alimentary canal another part is free to function. The tracheal lung enables the snake to inflate the anterior part of the body. This is conspicuous in the true venomous species (Solenoglypha). In the same way Heterodon inflates its huge diverticulum. In the marine water snakes Acrochordus and the Hydrophidæ these organs serve as floats. In the fresh-water snakes (Natricinæ) there is no tracheal lung.

III. HISTORY AND ACKNOWLEDGMENTS.

The first paper which called attention to the importance of the penial characters as indications of affinity in the Ophidia was published by me in the *American Naturalist* for December, 1893. The relations of the pulmonary structures to the systematic relations of the Ophidia were first pointed out by me in a paper published in the *Proceedings of the American Philosophical Society* for June, 1894. In the *American Naturalist* for October, 1894, I published an amended classification of the two subfamilies, Xenodontinæ and Philodryadinæ. In the *Proceedings of the Philadelphia*

Academy I published, in January, 1895, descriptions of the penial characters of several genera which I had not previously observed. The present memoir presents a number of modifications of the system as proposed by me in 1893. I have ceased to regard the more important penial structures observed as definitive of families, but rather of subfamilies. I have come to regard the flounced structure as of less importance than at first appeared, and I find it to be characteristic of genera and groups of genera only. On the other hand, I find the disciferous type to be quite distinct from all others and distinguish by it two subfamilies, the Xenodontinæ from the Dromicinæ, and the Erythrolamprinæ from the Philodryadinæ. I have combined the supposed Pseudaspidinæ with the Lycodontinæ. I have found the genus Chrysopelea to resemble the Dipsadinæ more closely than I had at first thought and have cancelled the supposed subfamily Chrysopeleinæ.

In preparing this memoir I have examined material belonging to the Museum of the Academy of Natural Sciences of Philadelphia, to the United States National Museum, and to the Philadelphia Museums, to whose officers my thanks are especially due. I wish to acknowledge also my indebtedness to Prof. Alexander Agassiz for the opportunity of examining some Australian species; to Prof. Charles S. Dolley for a collection from Hainan, China; and to Prof. Wright, of Oberlin, O., for a small but valuable collection from So .th Africa; to Mr. George K. Cherrie for a fine series from Costa Rica, and Drs. Ferrari-Perez, Bernad, Dugés and Villada for Mexican species. To Messrs. J. B. Wood and George Pine I am indebted for collections from Florida; to Prof. W. T. Cummins for material from Texas; and to Dr. Jos. Corson, U. S. A., for specimens from Mobile, Ala. I am also especially indebted to the Zoölogical Society of Philadelphia and its Superintendent, Mr. Arthur E. Brown, for specimens from the Gardens.

IV. SYSTEMATIC CONCLUSIONS.

Diversity of lung structure accompanies the primary groups which are characterized by peculiarities of the skeleton to such a degree that we are warranted in according it a high systematic value. Thus angiostomatous and peropodous snakes have two lungs, while the Colubroidea have one and a rudiment, and the Solenoglypha always have a tracheal lung. Exceptions and variations from these rules thus become of importance. Thus I have no doubt of the propriety of the separation of the Ungualiidæ from the other Peropoda, on account of its pulmonary characters. Nor is there any doubt in my mind of the necessity of the separation of the Leptognathinæ from the Dromicinæ, on account of its large tracheal lung. The very marked characters of the genus Acrochordus characterize the family, as well as the osteological

features. It remains to be seen whether the family I termed the Nothopidæ, but which Boulenger unites with the Acrochordidæ, agrees with it in pulmonary characters. The remarkable tracheal lung or gland distinguishes the Epanodonta from the Catodonta, emphasizing the differences observed in the osteology of the skull. The huge diverticulum of Heterodon serves to distinguish the genus from its allies. The extraordinary transverse dilatation of the trachea in Thrasops establishes the genus as distinct.

The value of the rudimental right lung as a character of the Colubroidea is increased by my investigations. In only two genera have I found it present or absent, viz., Halsophis and Pityophis. I am not sure but that I may yet find it in the *P. melanoleucus*, where I have failed hitherto, but I am sure that it is present in some species of Halsophis and wanting in others. A natural group of American Colubrinæ appears to be characterized by its absence, viz., Rhinochilus, Cemophora and Ophibolus, all genera with an entire anal shield. The development of cartilages in the bronchial foramen or tube of the rudimental lung, is not a constant character. I found it in one *Heterodon platyrhinus* and not in another; it is present in *Conophis pulcher*, but absent in *C. sumichrastii*.

The numerous characters presented by the hemipenis have various values. Several very distinct types are distinguishable, but they are continuous at some point through intermediate forms. This is, however, the history of all characters which distinguish organic beings, especially of those which have been relied on as characters of the minor divisions and genera of the Ophidia. The characters which I have discovered in the hemipenis have added greatly to our resources in the attempt to learn the relationships and hence origin of the members of the Ophidia.

In a broad way we may distinguish as leading types the following: The smooth, the plicate or flounced, the calyculate or ruched, and the disc-bearing. Any of these may have the sulcus spermaticus simple or bifurcate, and they may have the middle part of the organ spinous or not. The spines may extend to the apex so as to obliterate the pattern, and the total organ may be bifurcate or not. As regards the indications of affinity presented by these types, it may be said that the nearer we approach the Lacertilia the less spinous is the organ, and the farther away the form the more certainly will the ruched structure prevail. The tendency to bifurcation is present in most groups, but it is universal in but one suborder, the Solenoglypha, or specialized venomous snakes.

In the Oriental region we have the smoothest type of Colubroidea, which includes the genera really allied to Calamaria, many of which have had hitherto widely different positions in the systems. Owing to the scarcity of specimens of this type in

American museums, I have not been able to investigate them fully. The great Colubrine division is remarkably constant in its undivided sulcus and abundant calyces. In degenerate types the calyces become less numerous. The groove-toothed Dipsadines have the same structure. Except one Australian genus (Acanthophis), all the disciferous types are Neotropical, and all have a double sulcus. The other Neotropical types with double sulcus may be calyculate or spinous, and they present a great variety of detail. Here again the glyphodont and aglyphodont types are quite parallel to each other. The structure in the water snakes is again different and characteristic. The organ is feebly spinous from the base to or near to the apex, possessing no calyces, disc or transverse plicæ, and the prehensile function is maintained by one or a few large hook-shaped spines at the base. In 1864 I referred several genera which had been placed in the Calamarinæ to the water snakes on account of the continuation of the hypapophyses to the tail. I was much gratified on examining their hemipenis to find that they (genera Tropidoclonium, Virginia and Haldea) present exactly the characters of group to which the vertebræ indicated that they should be referred. On the other hand, the characters of the hemipenis in Ablabes (*baliodirus*) led me to suspect that it possesses the vertebral characters of the Natricinæ, and on examination this proved to be the case. In like manner I have been able to refer genera supposed to belong to the Calamarinæ to almost every natural division of the Colubroidea by the study of the hemipenis. The old Calamarinæ of authors is simply an aggregation of burrowing or degraded forms of several natural groups.

The Natricine (water snake) group is connected with the groove-toothed water snakes (Homalopsinæ), and both of these groups pass probably into the Lycodontine series, in the typical forms of which the spines are arranged in flounces. It is difficult as yet, and perhaps may not become easy, to distinguish some members of the Lycodont group from certain ground snakes with totally spinous hemipenis, especially certain African genera, as Elapops, Grayia and others. These questions remain for future research.

I have found the characters of the hemipenis as constant as those of any other part of the organism. Occasional irregularities are to be looked for, but the only one which I have met with is in the case of a specimen of *Boaodon infernalis* from South Africa, in which the hemipenis is shortly bifurcate on one side and not so on the other. There is a tendency to bifurcation in some individuals of *Ophibolus getulus* which is not conspicuous in others. It is a tendency only. There are seen in many species of all groups with calyces, ribs or welts having a longitudinal direction. On these the calyces are crowded and closed, and they are sometimes rudimental or distorted. I have not yet ascertained the constancy of these structures in species and genera,

excepting when they occur as borders of the sulcus spermaticus, where they are constant. These must not be confounded with temporary longitudinal folds of the structure, which can be removed by stretching.

I now give the exact definitions of the divisions as far as definable with present information. The definitions of the suborders are those of Müller, modified by myself.* An examination of the osteology of the skull led me, in 1859,† to place the genera Causus and Atractaspis in the order Solenoglypha. The former had been placed in the Proteroglypha by Duméril and Bibron, and the latter was made the type of a family "with permanently erect fangs" as division C of the second section of the Ophidia, the "Colubrinæ," by Günther.‡ My arrangement has been adopted by all later authors.

Authors have differed as to the homology of the bone which supports the quadrate in the Ophidia. Huxley§ has identified it as the element he called squamosal in the Lacertilia, a conclusion to which I have demurred ‖ for two reasons. The first of these is that this element is one of the bones of the brain-case in the Angiostomatous snakes, where it is intercalated between the exoccipital, parietal and petrosal. The second is, that the bone called by Huxley squamosal in the Lacertilia has no such intercalary relation, but is one of the segments of the primitive roof of the temporal fossa. In the degenerate snakelike forms of the Lacertilia this element disappears, and I believe that it does not exist in the Ophidia. I add that I agree with those osteologists who do not regard it as the homologue of the squamosal of the Mammalia, and who give it the name, after Owen, of supratemporal.¶

If we now remove the supratemporal from the skull of a Lacertilian we have the condition which exists in the Ophidia. We observe beneath the position of its posterior end, and between the exoccipital, parietal and petrosal, an element which corresponds with the bone in question in the Ophidia. This element has received various names, among the rest that of squamosal. I think I have shown, however, in view of the characters which it presents in the Pythonomorpha, that it is the paroccipital. By the lengthening of the exoccipital in the Lacertilia the paroccipital has been carried far from the brain-case and supports the quadrate behind. By its elongation posteriorly it has carried the quadrate posterior to the other bones of the skull in the Eurystomat-

* *Proceeds. Academy Philada.*, 1864, p. 230; *Proceeds. Amer. Philos. Soc.*, 1886, p 479.

† *Proceeds. Academy Philada.*, 1859, p. 335.

‡ *Catal. Colubrine Snakes* Brit. Museum, 1858, pp. 1 *et* 239.

§ *Anatomy of Vertebrated Animals*, 1872, pp. 189 and 203.

‖ "On the Homologies of the Cranial Bones of the Reptilia," *Proceeds. Amer. Assoc. Adv. Science*, 1871, pp. 174 and 217.

¶ *Transactions Amer. Philos. Soc.*, 1892, p. 20.

ous Ophidia. Huxley called the paroccipital of the Reptilia the opisthotic, hence in my first determination (in 1871) I used the latter term for it in the Ophidia.

A. Paroccipital intercalated in the cranial walls (*Angiostomata*).

* No ectopterygoid; palatines bounding choanæ posteriorly; ethmoturbinal forming part of roof of mouth; rudiments of pelvis; two lungs.

I. Maxillary bone fixed to prefrontal and premaxillary; a pubis.....CATODONTA.

II. Maxillary bone vertical and free from all others; no pubis.....EPANODONTA.

** An ectopterygoid; palatines not bounding choanæ posteriorly.

III. Maxillary bone free, horizontal.....TORTRICINA.

B. Paroccipital attached scale-like to cranial walls and produced freely; ectopterygoid present (*Eurystomata*).

IV. Maxillary bone horizontal, not forming a ginglymus with prefontal.....COLUBROIDEA.

V. Maxillary bone vertical and articulating with the prefrontal by a ginglymus; a tracheal lung. SOLENOGLYPHA.

Within these suborders the pulmonary characters define superfamilies and families. The penial characters, as already remarked, have various values, generally defining subfamilies and genera or groups of genera. These are given in the analytical tables under the family and subfamily heads. On examining these tables it will be seen that the genera brought into close juxtaposition are frequently not most closely allied in general appearance. *The keys are chiefly intended to present the penial characters, and do not always display the serial or other relationships of the genera among themselves.* The intimate filiations of the genera among themselves are not yet sufficiently well known to make it possible to do otherwise at present.

EPANODONTA.

I have nothing to add to what has been already stated regarding this suborder (p. 191).

CATODONTA.

What is known of this suborder has been already mentioned (p. 191).

TORTRICINA.

In Ilysia the hemipenis is deeply bifurcate and the surface of each branch is flounced. The flounces are oblique to the sulcus and are spineless. Below the bifurcation the surface is smooth, excepting a wart (Plate XIV, Fig. 1).

COLUBROIDEA.

Five well-marked divisions are embraced in this suborder, as follows:

I. Chevron bones open inferiorly.

Rudimental pelvis and posterior limbs; no grooved teeth; generally two lungs.....PEROPODA.

No rudimental pelvis or limbs nor grooved teeth; one lung rudimental.....AGLYPHODONTA.

No rudimental pelvis or limbs; a posterior maxillary tooth or teeth, grooved; one lung rudimental. GLYPHODONTA.

No rudimental pelvis or limbs; an anterior tooth with tube for poison duct; one lung rudimental. PROTEROGLYPHA.

II. Chevron bones complete, the lateral halves united below.

No rudimental limbs; a tubular tooth in front of mouth; one principal normal lung and a tracheal lung..... PLATYCERCA.

It is questionable whether the Aglyphodonta and Glyphodonta should be retained as distinct from each other. Most of the penial characters found in the one occur in the other, and it remains to ascertain whether these, or the grooving or not of the teeth, are to be considered to be of primary importance. For the present I follow the example of Duméril and Bibron and Boulenger.

PEROPODA.

I find here three distinct families, as follows:

Two pulmonary lungs, no tracheal lung; nasal bones distinct; a coronoid bone: hemipenis plicate. *Boidæ.*

Two pulmonary lungs; no tracheal lung; nasal bones coössified; no coronoid bone; hemipenis plicate..... *Charinidæ.*

One pulmonary lung, a tracheal lung; two nasal and a coronoid bone; hemipenis smooth..* *Ungualiidæ.*

Boidæ.

Within this family the characters of the hemipenis vary considerably. The plicæ are more or less undulate, and in some genera they fuse at intervals, producing pockets which sometimes approach the character of calyces. The sulcus and generally the entire organ are bifurcate. The plicæ may also be represented at the apex by distinct papillæ. The genera which I have examined present the following characters:

I. Sulcus double.

a. Hemipenis single.

Plicate and not papillose..... † *Eryx* Daud.

aa. Hemipenis furcate.

Entirely plicate..... ‡ *Boa* Linn; § *Eunectes* Wagl.

More or less pocketed..... ‖ *Lichanura* Cope. ¶ *Python* Daud. ** *Enygrus* Wagl.

Apex papillose..... †† *Epicrates* Wagl.

II. Sulcus single.

Apex papillose..... ‡‡ *Chilabothrus* D. and B.

The sulcus in the *Chilabothrus striatus* examined is divided for a short distance when the branches reunite; Pl. XV, Fig. 3.

* Cope, *Proceeds. Amer. Philos. Soc.*, 1894, p. 220.

† *E. jaculus.* ‡ *B. constrictor.* § *E. murinus.* ‖ *L. trivirgata.*

¶ *P. (Morelia) argus.* ** *E. carinatus.* †† *E. angulifer.* ‡‡ *C. striatus.*

Several forms of this family I have not been able to examine, as Chondropython, Sanzinia, Bolieria, Trachyboa, etc.

Charinidæ.

In Charina the sulcus is bifurcate, but the organ is simple. The surface is plicate, the plicæ distant towards the apex, and the apex smooth (Pl. XIV, Fig. 3).

Ungualiidæ.

In Ungualia there are no plicæ, and in *U. melanura* there are only four small papillæ symmetrically arranged. The sulcus and organ are furcate (Pl. XV, Fig. 8).

AGLYPHODONTA.

The three families of the Aglyphodonta are defined as follows:

Two pulmonary lungs; no tracheal lung; a coronoid bone.....*Xenopeltidæ.*
One pulmonary lung and a tracheal lung; no coronoid bone; postfrontal bone produced forwards over the orbit.....*Acrochordidæ.*
One pulmonary lung, with a rudiment of a second; rarely a tracheal lung; no coronoid bone; postfrontal bone not produced over orbit.....*Colubridæ.*

I have been unable to determine the penial structure of the only species of the **Xenopeltidæ,** the *Xenopeltis unicolor* Reinwt. as all of the four individuals accessible to me are females.

Acrochordidæ.

There are two subfamilies of this family.

No gastro- or urosteges.....*Achrochordinæ.*

Of the members of this subfamily I have only examined the hemipenis of *Acrochordus javanicus* and *A. granulatus* Cuv. This is bifurcate but not deeply, and the surface below the bifurcation is smooth. The branches are delicately and not closely spinous (Pl. XV, Fig. 13). It is not certain that the Nothopinæ belong to this family or to a distinct one; the cranial structure is identical. They differ from the Achrochordinæ as follows:

Gastro- and urosteges present.....*Nothopinæ.*

Colubridæ.

The natural divisions of this family are clearly indicated by the characters of the hemipenis for the greater part. The characters of the vertebræ cannot, however, be neglected; and the dentition, in a general way, corresponds with the results thus attained. Thus the type of penis with simple sulcus and well-developed ruches

includes the large isodont ground snakes and their allies, a very few of which (Zamenis *sp.*) are diacranterian. The types with furcate sulcus with ruches or disc are nearly always diacranterian in dentition. The Natricine hemipenis is always associated with continued vertebral hypapophyses. The smooth or plicate hemipenis is very seldom associated with such hypapophyses.

I repeat here in the main the groups indicated in my prodromus of 1893, with the omission of the glyphodont genera. As I have not had access to some of the Oriental and African genera, it may be necessary to introduce some changes into some of the groups which include them.

I. Hypapophyses restricted to the anterior part of the vertebral column.

a. No tracheal lung.

Hemipenis spineless, smooth, plicate or papillose only.....*Calamarinæ*.
Hemipenis with apical disc; no calyces; spinous; sulcus furcate.....*Xenodontinæ*.
Hemipenis calyculate, spinous; sulcus furcate; no disc.....*Dromicinæ*.
Hemipenis calyculate, spinous; sulcus simple; no disc.....*Colubrinæ*.

aa. A tracheal lung.

Hemipenis as in Dromicinæ.....*Leptognathinæ*.

II. Hypapophyses present to the caudal region. Hemipenis without calyces.

Hemipenis smooth, not spinous.....*Anoplophallinæ*.
Hemipenis spinous, without enlarged basal hook.....*Lycodontinæ*.
Hemipenis minutely spinous, with enlarged basal hook or hooks.....*Natricinæ*.

CALAMARINÆ.

The genera of this group are of various external form and the hemipenis presents considerable variety of structure.

I. Fusiform.

Hemipenis smooth, simple; sulcus furcate.....* *Calamaria* Boie.
Hemipenis transversely plicate; sulcus simple; extremity with two papillæ.....† *Oligodon* Boie.
Hemipenis smooth or nearly so; apex membranous; sulcus simple.....‡ *Holarchus* Cope.
Hemipenis similar to Holarchus, but sulcus furcate.....§ *Dicraulax* Cope.

II. Colubriform.

Hemipenis single, apex papillose.....*Grayia* Gthr.

III. Dipsadiform.

Hemipenis bifurcate, with papillæ at the middle, and smooth apex.....‖ *Pareas*.

It is probable that several genera allied to Calamaria resemble it in characters, and that Simotes D. and B. belongs near to Holarchus. From their general resemblance it is also probable that Anoplodipsas Pet. and Amblycephalus Kuhl belong near to Pareas. The subfamily is entirely Oriental, except Grayia, which is African.

* Species examined: *C. gervaisii*. † *O. subquadratus*. ‡ *H. ancorus, H. dolleyanus*.
§ *D. purpurascens trinotatus*. ‖ *P. moellendorffii* Boettg.

XENODONTINÆ.

After the subtraction of the Dromicinæ, a limited number of genera are referable here. They are all Neotropical.

φ. Rostral plate not recurved.

Hemipenis undivided; no scale-pits ..... *Aporophis* Cope.
Hemipenis divided; no scale-pits ..... *Opheomorphus* Cope.
Hemipenis divided; one scale-pit ..... * *Xenodon* Boie.

φφ. Rostral plate recurved.

Hemipenis divided; one scale-pit ..... *Lystrophis* Cope.

DROMICINÆ.

A. No proximal diverticulum of the left lung.

I. Hemipenis transversely plicated (divided); (Flabellati).

Plicæ not papillose; diacranterian; colubriform ..... *Helicops* Wagl.
Plicæ not papillose; isodont; fusiform ..... *Pseudoeryx* Fitz.
Plicæ papillose; isodont; fusiform ..... *Rhabdosoma* D. & B.

II. Calyculate and not capitate (Calyculati).

φ. Hemipenis undivided.

Fusiform; isodont ..... *Carphophiops* Gerv.
Colubriform; isodont; two nasals ..... *Diadophis* B. & G.
Colubriform; diacranterian; one nasal ..... *Amastridium* Cope.
Colubriform; diacranterian; two nasals ..... *Hypsirhynchus* Gthr.

φφ. Hemipenis double.

Fusiform; isodont ..... *Farancia* Gray.
Colubriform; diacranterian; no scale-pits ..... *Dromicus* Bibr.
Colubriform; diacranterian; one scale-pit ..... † *Monobothris* Cope.
Colubriform; diacranterian; two scale-pits ..... *Halsophis* Cope.

III. Capitate (or pocketed at base of calyculate portion) (Capitati).

φφ. Hemipenis undivided.

Scale-pits single; scales smooth ..... *Pliocercus* Cope.
No scale-pits; scales smooth ..... *Rhadinæa* Cope.
Scales keeled; prenasals in contact ..... *Tretanorhinus* D. & B.

φφ. Hemipenis divided.

Rostral normal; isodont ..... *Ninia* B. & G.

IV. Calyculate with spinous bands to apex (Calycispinosi).

Hemipenis bifurcate; spines not ossified to apex; diacranterian; colubriform ..... ‡ *Tæniophallus* Cope.
Hemipenis bifurcate; subisodont; attenuate ..... *Uromacer* D. & B.

V. Exclusively spinous to apex; (diacranterian) (Spinosi).

Anterior teeth wanting ..... *Enulius* Cope.
Anterior teeth present; internasals fused; fusiform ..... § *Hydrops* Wagl.
Anterior teeth present; anal divided; no scale-pits; colubriform; not bifurcate ... ‖ *Echinanthera* Cope.
Anterior teeth present; anal entire; one scale-pit; colubriform; bifurcate ..... *Acanthophallus* Cope.

AA. Left lung with a proximal diverticulum extending to the throat.

VI. Calyculate and capitate.

Rostral recurved; hemipenis divided; diacranterian ..... *Heterodon* Beauv.

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* Includes Liophis Wagl.
† Type *Dromicus chamissonis* Auct.
‡ Type *Lygophis nicagus* Cope. Pockets separate the spinous bands from the calyces.
§ *H. martii* Wagl. examined.
‖ Type *Aporophis cyanopleurus* Cope.

The species of this subfamily are all American and mostly Neotropical. The following genera are found in the Nearctic fauna: Carphophiops, Diadophis, Farancia, Rhadinæa (*Dromicus flavilatus* Cope, from the Southeast Atlantic region, belongs to this genus: Pl. XXVII, Fig. 6), Heterodon. Of these all are characteristically Nearctic, except Rhadinæa, which is Neotropical. I have given a synopsis of the genera of Dromicinæ in the *American Naturalist* for October, 1894, p. 840.

LEPTOGNATHINÆ.

The three genera of this family are distinguished as follows:

Gular region with two longitudinal pairs of plates ..... *Petalognathus* D. & B.
Gular region with numerous paired plates ..... *Leptognathus* D. & B.
Gular region with a median plate ..... *Mesopeltis* Cope.

The hemipenis in the subfamily Leptognathinæ is not bifurcate, but the sulcus is deeply so. It is calyculate from the bifurcation of the sulcus to the extremity and the calyces are fringed. Below them the organ is furnished with hooked spines half way to the base. Below these the surface is smooth. In *Mesopeltis sanniolus* the calyces have longer papillæ than in the other species which I have examined.

COLUBRINÆ.

This subfamily includes representatives of the Calamarinæ, Coronellinæ, Lycodontinæ, Colubrinæ and Dryadinæ of authors, and includes burrowing, ground and arboreal types. The group is especially characteristic of Palearctica and Nearctica, but numerous forms occur also in the Oriental, Ethiopian and Neotropical realms. There is a general similarity in penial structure, the diversities being of minor importance, and some of them not yet fully understood. I have been able to abolish the division Coronellinæ, which never had any real standing, and also to show that Hallowell was right when he referred the *Lycodon rufozonatus* of authors to the neighborhood of Coronella. The genera of burrowing habits and generally small size which were variously referred to the Calamarinæ and Coronellinæ, generally have the ruching of the hemipenis reduced and replaced by spines. This is conspicuous in Stylosoma and especially in Conopsis, where there is but one row of calyces, and in Adelphicus and Trimetopon, where the cups are replaced by unossified papillæ. In the species of Ophibolus the calyces are much reduced in number and replaced by spines. Some genera have the borders of the calyces conspicuously papillose, while in others they are smooth, but intermediate conditions connect them. In some forms there are smooth patches on the apex of the organ, but the value of this character is uncertain. In Cynophis I have found a remarkable apical awn, but as I have had the opportunity of

examining but one individual, I am not sure how constant it is. In the *Tropidoclonium lineatum*, where a similar character is present, I have found it to be entirely constant.

Boulenger distinguishes two principal divisions of ground Colubridæ as genera, under the names Zamenis and Coluber, on dental characters. In the former the maxillary teeth increase in size posteriorly, while in the latter the posterior teeth are not longer, and may be shorter than the anterior. That this distinction is valid in many instances is well known, but it is admitted by Boulenger that in other instances the transitions are complete. An examination of the penial characters leads me to the opinion that each of these groups is a series of genera rather than a single genus. Thus in the *Zamenis gemonensis*, the type of the genus, we have the normal colubrine structure, from which two divergent lines may be traced. In one of these, represented by the *Z. ventrimaculatus*, the calyces preserve their character, but the few papillæ are ossified as acute spines, the character defining the genus Acanthocalyx. In another direction the walls of the calyces are thickened and support several series of papillæ. This is seen in the *Z. ravergierii*. In the next type these numerous papillæ are ossified, giving us the genus Gonyosoma. A greater modification is seen in the *Z. florulentus*. Here the thickening of a part of the calyx walls is greatly increased, while other walls, including all of the longitudinal ones, disappear. The result is a mass of papillose pads, a character quite different from anything else in the order, and one which defines the genus Tylanthera. The explanation of this structure is rendered possible by that of the *Zamenis ravergierii* (Pl. XVI, Fig. 4).

The North American species referred to Zamenis by Boulenger have been separated under the name Bascanium by Baird and Girard. Most, if not all, of these species differ from the typical *Zamenis gemonensis* in possessing one or two large hooks at the proximal part of the spinous tract (Pl. XVIII, Fig. 1) which remind one of the Natricinæ, and which are not found in the typical forms of Zamenis.* The *Drymobius pulcherrimus*† Cope possesses a similar peculiarity, which separates it from the typical species of that genus. It differs from the species of Bascanium, however, in having the large spines distad to the spinous tract and not proximad (Pl. XVIII, Fig. 4).

In the species of Coluber there are distinct naked tracts or bands extending more or less downwards from the apex (Pl. XVI, Fig. 2; Pl. XXI, Fig. 3). There is one strongly pronounced in *C. emoryi* and there are two less extensive in *C. obsoletus*.

*This character is present in *B. flagelliforme*, *B. laterale*, *B. mentovarium* and *B. mexicanum* (Zamenis D. & B.). In *B. constrictor* it is sometimes present and sometimes absent (see Pl. XIV, Fig. 6).

†The species figured and described by Bocourt (*Miss. Sci. Mexique*, p. 725, Pl. XLIX, Fig. 3) under this name is quite distinct. It is much larger, has but two preoculars, four bands instead of two, and is olive and brown instead of black and white with a green head. I propose to call it *Drymobius lemniscatus*.

I give the following synopsis of the genera so far as I have been able to examine them:

I. Hypapophyses not piercing œsophagus.

* Apical calyces of hemipenis present.

A. Calyces with the borders spinous.

Spines at angles of calyces only ; colubriform ; scuta normal ; teeth longest posteriorly. **Acanthocalyx* Cope.

Spines numerous, bordering the calyces ; colubriform ; scuta normal ; teeth equal.... *Gonyosoma* Wagl.

AA. Calyces with spines on the internal walls.

Calyces numerous, fringed ; scuta normal ; one nasal plate.....† *Entechinus* Cope.

AAA. The calyces, excepting the inferior marginal ones, not furnished with spines.

α. No apical awn or papilla.

β. Calyces normal ; *i. e.*, small and deep.

γ. Hemipenis not capitate.

δ. Calyces mingled with large pockets.

Isodont ; attenuate ; ventrals keeled .....*Dendrophis* Boie.

δδ. Calyces without large pockets ; ventrals not keeled.

ε. Rostral normal or compressed ; pupil round.

ζ. Anterior teeth not longer than posterior.

η. Two median rows of scales.

Colubriform ; isodont ; anal double.....‡ *Herpetodryas* Boie.

Colubriform ; isodont ; anal single.....§ *Spilotes* Wagl.

ηη. One median row of scales.

θ. Trachea enormously expanded transversely.

Subisodont ; dipsadiform.....*Thrasops* Hallow.

θθ. Trachea normal.

ι. Calyces numerous, fringed.

κ. One nasal plate.

Isodont ; colubriform ; anal divided .....*Cyclophis* Gthr.

Isodont ; coronelliform ; anal divided.....*Contia* B. & G.

κκ. Two nasal plates.

Anal divided ; no epiglottis ; attenuate.....*Leptophis* Bell.

Anal divided ; no epiglottis ; colubriform ; teeth longer posteriorly.....*Zamenis* Wagl.

Anal divided ; no epiglottis ; colubriform ; teeth equal.....*Coluber* Lim.

As Coluber, but anal entire .....‖ *Compsosoma* D. & B.

As Compsosoma, but rostral prominent and compressed.....*Rhinechis* Wagl.

As Compsosoma, but an epiglottis.....*Epiglottophis* Cope.

Anal entire ; rostral prominent, produced backwards ; four prefrontals ; an epiglottis...*Pityophis* Holbr.

Anal entire ; plates normal ; coronelliform.....*Osceola* B. & G.

ιι. Calyces numerous, not fringed.

Attenuate ; dipsadiform ; isodont.....*Bucephalus* Smith.

Posterior teeth longer ; coronelliform ; anal divided ; one scale-pit.....*Coronella* Laur.

Teeth subequal ; coronelliform ; anal divided ; two scale-pits ; pupil round.....*Proterodon* Hallow.

Colubriform ; anal divided ; internasal and nasal united.....*Symphimus* Cope.

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* Type *Zamenis ventrimaculatus* Gray.

† Type *Cyclophis major* Gthr.

‡ Zaocys Cope is apparently allied to this genus, but I do not know the penial structure.

§ Includes *Herpetodryas fuscus*, where the anal is sometimes divided.

‖ This is Phrynonax Cope, Boulenger. Compsosoma has priority, and the penial structure is identical.

ιιι. Calyces few, apical.

Subisodont; coronelliform: two nasals; a loreal; anal entire..... *Ophibolus* B. & G.

Isodont; fusiform; one nasal; no loreal; anal entire..... *Stylosoma* Brown.

ζζ. Median and posterior teeth longer than the others.

Coronelliform; pupil erect; calyces not fringed..... *Dianodon* D. & B.

εε. Rostral plate produced or recurved.

ζ. Rostral not free laterally; pupil round.

η. Subcaudals one-rowed.

Internasals distinct; calyces few..... *Rhinochilus* B. & G.

ηη. Subcaudals two-rowed.

θ. Internasals fused with nasals.

Fusiform; isodont; rostral depressed; calyces fringed..... *Chilomeniscus* Cope.

θθ. Internasals not fused with nasals.

Rostral trihedral; internasals present; anal entire; calyces not fringed..... *Cemophora* Cope.

Rostral recurved; no internasals; calyces numerous, fringed; anal divided..... *Ficimia* Gray.

Rostral not recurved; nasals distinct from labials; calyces numerous; anal divided.....* *Geagras* Cope.

Rostral not recurved; nasals distinct from labials; calyces very few..... *Conopsis* Gthr.

ζζ. Rostral plate free laterally; pupil erect.

Colubriform; subisodont..... *Phyllorhynchus* Stejn.

γγ. Hemipenis capitate.

Pupil round; rostral free laterally..... *Salvadora* B. & G.

Pupil erect; rostral normal..... *Hypsiglena* Cope.

ββ. Calyces basin-like, large and shallow.

Isodont; colubriform; anal divided.....† *Cacocalyx* Cope.

αα. An awn-like apical papilla.

Colubriform; scuta normal..... *Cynophis* Gray.

** Calyx borders represented by tufts, which are divided into numerous papillæ.

Teeth longer posteriorly; scuta normal; colubriform.....‡ *Tylanthera* Cope.

*** Calyces split up into separate papillæ.

A preocular and one prefrontal plate..... *Trimetopon* Cope.

No preocular and two prefrontals..... *Adelphicus* Jan.

II. Anterior hypapophyses piercing the walls of the œsophagus.

α. Spines in transverse or flounced rows.

Calyces numerous, fringed; scuta normal; one nasal; dipsadiform..... *Dasypeltis* Wagl.

ANOPLOPHALLINÆ.

Sulcus undivided; surface with transverse papillose flounces; colubriform; anterior teeth longer. § *Anoplophallus* Cope.

LYCODONTINÆ.

This group is intermediate in penial character between several others. It is allied to the Calamarinæ through Grayia, and to the Dromicinæ through Homalosoma. Pseudaspis shows resemblance in the hemipenis to the Natricinæ, and Anomalodon is

* *G. frontalis* Cope examined.

‡ Type *Zamenis florulentus* Geoffr., Western Asia.

† Type *Drymobius percarinatus* Cope, Costa Rica.

§ Possibly this is Nymphophidium Gthr.

similar to Homalopsis. I find that the flouncing of the penial structure is not sufficient to define the group as I at first thought.

I. Sulcus spermaticus undivided.

a. Teeth continuous, longer posteriorly.

Hemipenis spinous to apex, flounces indistinct; pupil round, nostril in prenasal; fusiform. **Elapops* Gthr.

aa. Teeth interrupted; longer in front.

Hemipenis flounced at apex; pupil erect; colubriform ..... *Lycodon* Boie.

II. Sulcus spermaticus double.

a. Teeth longer anteriorly. (Hemipenis bifurcate.)

Hemipenis spinous to apex, not flounced; nostril in prenasal ..... †*Lycophidium* Fitz.

Hemipenis spinous, flounced; anterior teeth separated from posterior by a space ..... *Boaodon* D. & B.

Hemipenis spinous, flounced; maxillary teeth in a continuous series ..... *Lamprophis* Fitz.

aa. Teeth not longer anteriorly. Hemipenis not flounced.

Hemipenis not bifurcate ..... *Homalosoma* Wagl.

Hemipenis bifurcate ..... *Pseudaspis* Cope.

aaa. Teeth much longer posteriorly. (Hemipenis bifurcate.)

Colubriform; rostral normal; spines very sparse ..... ‡*Dromicodryas* Boul.

Coronelliform; rostral trihedral, prominent; spines very numerous ..... *Anomalodon* Jan.

The above genera are all Ethiopian, except Lycodon, which is Oriental.

NATRICINÆ.

We have here a well-defined and homogeneous group, which is distributed in the Northern Continents and the Oriental region. A species is said to be found in the Ethiopian, but I have not yet been able to examine its penial characters. I have ascertained that the genus Ablabes (type *A. baliodirus* by exclusion) belongs to this subfamily, and is characterized by an entirely unique penial structure, which places it in a section by itself.

I. Enlarged basal spines in symmetrical fasciculi. Sulcus undivided.

Two fasciculi on each side of the sulcus, the proximal pair nearly surrounding the base; both containing spines which are closely packed and issue from their fleshy margins; hemipenis undivided; scuta normal. ..... *Ablabes* D. & B.

II. Enlarged spines isolated and more or less unsymmetrical.

A. Sulcus undivided.

a. Two large apical papillæ.

Scuta normal; anal entire ..... *Tropidoclonium* Cope.

aa. No apical papillæ.

β. No preocular plate.

One internasal; anal divided; scales keeled ..... *Haldea* B. & G.

Two internasals; scales keeled; anal divided ..... *Amphardis* Cope.

Two internasals; scales smooth; anal divided ..... *Virginia* B. & G.

ββ. Preocular present.

No loreal; anal divided; two internasals ..... *Storeria* B. & G.

* Vertebræ not seen. † *L. laterale* Hallow. examined. ‡ Lianthera Cope, *Amer. Naturalist*, 1893, p. 482.

A loreal; anal entire; two internasals.....*Eutænia* B. & G.
A loreal; anal divided; one internasal.....*Liodytes* Cope.
A loreal; anal divided; two internasals.....**Natrix* Laur.

AA. Sulcus bifurcate. (Hemipenis furcate.)

Two apical papillæ; plates as Natrix.....*Ceratophallus* Cope.
No papillæ; plates as Natrix.....†*Bothrodytes* Cope.
No papillæ; one prefrontal plate.....‡*Trimerodytes* Cope.

GLYPHODONTA.

This superfamily presents no such diversity of character as to indicate that it embraces more than one family, the **Dipsadidæ.** The subfamilies of the Dipsadidæ correspond quite closely with those of the Colubridæ. They are defined as follows:

I. Hypapophyses of vertebræ anterior only; hemipenis spinous.

Calyculate; sulcus undivided.....*Dipsadinæ.*
Calyculate; sulcus bifurcate.....*Scytalinæ.*
Not calyculate; an apical disc.....*Erythrolamprinæ.*

II. Hypapophyses extending throughout column.

Not calyculate; no basal hook nor apical disc.....*Homalopsinæ.*

These subfamilies correspond with those of the Colubridæ as follows:

COLUBRIDÆ.	DIPSADIDÆ.
Xenodontinæ,	Erythrolamprinæ,
Dromicinæ,	Scytalinæ,
Colubrinæ,	Dipsadinæ.
Lycodontinæ.	Homalopsinæ.

The distribution of the subfamilies of corresponding pairs is nearly identical. Thus the first two of both columns are South American, and the third of both columns is nearly cosmopolitan. The fourth group of each column is restricted to the African and Oriental regions. Still closer correspondences will be pointed out in the characters of some of the genera of corresponding subfamilies.

ERYTHROLAMPRINÆ.

In this subfamily the sulcus and hemipenis are bifurcate in the known genera.

I. Hemipenis generally spinous; disc at the extremity of the sulcus.

Coronelliform; scuta normal; disc smooth.....*Erythrolamprus* Boie.

II. Hemipenis with spines in two bands only; disc at one side of the sulcus.

Attenuate; scuta normal; disc papillose; spines joined by a longitudinal membrane...§*Lygophis* Tsch.

SCYTALINÆ.

I. Hemipenis transversely or obliquely plicate (divided). (Flabellati.)

No calyces; rostral plate normal.....*Jaltris* Cope.
Calyces at apex; rostral plate produced.....*Conophis* Peters.

* Including Amphiesma D. & B. † Including Diplophallus Cope. ‡ *Proceeds. Acad. Phila.*, 1894, p. 426.
§ Cope, definition, *Amer. Naturalist*, 1894, p. 84.

II. Calyculate and not capitate. (Calyculati.)

φ. Hemipenis divided.

Rostral recurved.....*Rhinostoma* Wagl.
Rostral normal; pupil erect.....*Oxyrrhopus* Wagl.
Rostral normal; pupil round.....*Philodryas* Wagl.

φφ. Hemipenis undivided.

Rostral normal.....*Thamnodynastes* Wagl.

III. Capitate (also calyculate). (Capitati.)

Hemipenis undivided; colubriform.....*Coniophanes* Hallow.
Hemipenis undivided; fusiform.....*Hydrocalamus* Cope.

IV. Spinous to apex (divided). (Spinosi.)

Two nasal plates.....*Tachymenis* Wiegm.
One nasal plate.....*Tomodon* D. & B.

V. Bands of spines extending to apex. (Calycispinosi.)

Spines of bands minute; caudal scuta one-rowed.....*Scytale* Wagl.

The groups into which this subfamily is divided correspond closely with those which are found in the subfamily Dromicinæ. The group VI, including only the genus Heterodon, is the only one of the latter which is not represented in the former. Apart from penial characters, the genera of the corresponding groups sometimes resemble each other, but frequently they do not. Thus Alsophis resembles Philodryas, and Rhadinæa resembles Coniophanes, and Acanthophallus resembles Tomodon in general characters.

DIPSADINÆ.

I. Apex flounced. (Flabellati.)

α. Fusiform.

Internasals distinct; flounces spinous; subcaudals one-rowed.....*Uriechis* Pet.
Internasals distinct; flounces spinous; subcaudals two-rowed.....*Urobelus* Rhdt.
Internasals and nasals fused; flounces not spinous; subcaudals two-rowed.....*Stenorhina* D. & B.

αα. Attenuate.

Calyces large, irregular; gastrosteges angulate.....*Chrysopelea* Boie.

II. Calyculate, not capitate. (Calyculati.)

α. Dipsadiform (head short, very distinct from neck).

β. No spines on hemipenis.

Calyces numerous.....* *Dipsadomorphus* Gthr.

ββ Spines present.

Calyces numerous.....*Dipsas* Laur.
Calyces very few.....*Crotaphopeltis* Fitz.

αα. Attenuate.

β. No diverticulum.

Pupil horizontal.....*Cladophis* Dum.
Pupil round.....*Oxybelis* Wagl.

ββ. Hemipenis with a diverticulum.

Pupil round.....*Dryophis.*

* Liophallus Cope, *Proceeds. Acad. Phila.*, 1894, p. 427.

aaa. Fusiform.

β. A loreal plate.

Tail abbreviated, rough.....*Procinura* Cope.
Tail normal; one nasal.....* *Elapomorphus* Wieg.
Tail normal; two nasals.....*Scolecophis* Cope.

ββ. No loreal.

Two pairs of genials.....*Tantilla* B. & G.
One pair of genials.....*Pogonaspis* Cope.

III. Calyculate and capitate. (Capitati.)

Calyces numerous; colubriform; anal double.....*Sibon* Fitz.

IV. Spinous to apex. (Spinosi.)

Fusiform; rostral prominent; anal divided.....*Ogmius* Cope.

V. Apex with longitudinal plicæ; calyces few and irregular.

Spines few; head very distinct; anal scutum double.....*Trimorphodon* Cope.

The groups of Dipsadinæ from I to IV inclusive correspond in penial characters to the groups similarly numbered in the Dromicinæ and Scytalinæ respectively. Group *aa* of Division I resemble in the same characters the Lycodontinæ, with which I at first associated them.

HOMALOPSINÆ.

I. Flounced; sulcus bifurcate.

Hemipenis bifurcate; spines numerous, small; one internasal; nasal plates not in contact behind rostral. *Cantoria* Gird.

Hemipenis as in Cantoria, except that there are large spines below bifurcation; nasal plates in contact behind rostral.....† *Hypsirhina* Wagl.

II. Not flounced; sulcus bifurcate (hemipenis bifurcate).

a. No tentacles on muzzle.

Spines numerous; one internasal plate; parietals undivided.....*Homalopsis* Kuhl.
Spines numerous; two internasal plates; parietals subdivided.....*Cerberus* Cuv.

aa. Tentacles on muzzle.

Spines numerous; one internasal; parietals undivided; tentacles lateral; robust.....*Herpeton* Lac.
Spines feeble, minute; parietals undivided; tentacle median; attenuate.....*Langaha* Brug.

PROTEROGLYPHA.

I have been able to examine a limited number of species of this superfamily, and must therefore present an imperfect synopsis of the genera. I have examined enough of the species to affirm that they present variations of type similar to those seen among the superfamilies already considered. All the forms that I have seen have a bifurcate sulcus and all are spinous.

There are three families, as follows:

A postfrontal bone; fang grooved.....*Najidæ*.
No postfrontal bone; fang grooved.....*Elapidæ*.
A postfrontal; fang not grooved in front.....*Dendraspididæ*.

* Phalotris and Apostolepis probably belong here.

† *H. bocourtii* Vaill. examined.

Najidæ.

I. Apex of hemipenis smooth, with ruched free margin. (Disciferi.)

No solid maxillary teeth ; subcaudals one-rowed ; hemipenis bifurcate.....*Acanthophis* Daud.

II. Apex with calyces. (Calyculati.)

a. Spinous below calyces.

Subcaudals one-rowed ; vertebral row enlarged ; hemipenis not divided.....*Bungarus* Daud.

Subcaudals two-rowed ; vertebral row not enlarged ; poison gland far posterior to head ; hemipenis not divided ; no solid teeth.....*Adeniophis* Meyer.

Hemipenis divided ; calyces not fringed ; no flounces ; subcaudals two-rowed ; no solid teeth. *Sepedon* Merr.

Hemipenis divided, the branches extensively flounced below calyces ; solid teeth.....*Ophiophagus* Gthr.

aa. Not spinous below calyces.

Hemipenis bifurcate ; calyces fringed ; anterior ribs elongate, erectile .....*Naja* Laur.

Hemipenis bifurcate ; anterior ribs not elongate or erectile ; solid teeth.....**Diemenia* Gray.

III. Apex papillose.

Hemipenis simple ; urosteges one-rowed ; rostral normal ; solid teeth.....*Hoplocephalus* Cuv.

Dendraspididæ.

The single genus of this family is characterized as follows :

Sulcus bifurcate ; hemipenis simple ; calyculate, becoming spinous at middle ; no teeth behind fang ; attenuate.....†*Dendraspis* Schl.

Elapidæ.

The only genera of this family which I have examined are Elaps and Vermicella. The hemipenis is alike in both, *i. e.*, it is bifurcate, with each half with a spinous apex. The extension of the spines downwards differs with the species. Thus they extend but a short way in *Elaps corallinus*, but extend far down in *E. surinamensis* and *E. imperator* (see Pls. XXXI, XXXII).

PLATYCERCA.

But one family, the **Hydrophidæ,** is included in this division. I have been able to examine but two genera, Hydrus and Hydrophis. Specimens of Platurus at my disposal are all females.

Hemipenis undivided ; spinous to near apex, where it is papillose.....*Hydrophis* Daud.

Hemipenis undivided, spinous to apex.....*Hydrus* Shaw.

SOLENOGLYPHA.

The families of the Solenoglypha are the following :

Maxillary bone not excavated ; fang not grooved in front ; no postfrontal bone.....*Atractaspididæ* Gthr.

Maxillary bone not excavated ; fang grooved in front ; a postfrontal.....*Causidæ* Cope.

Maxillary bone not excavated ; fang not grooved ; a postfrontal .....*Viperidæ* Gray.

Maxillary bone excavated by a large chamber ; fang not grooved in front ; a postfrontal. *Crotalidæ* Gray.

* Only species examined, *D. annulata*, (*Naja*) Buch. and Peters, West Africa. † *D. jamesonii* Traill.

The penial characters of the Solenoglypha are like those of the more specialized members of the Colubroidea, and vary in the same way, except that the sulcus and the organ are always bifurcate.

Atractaspididæ.

The genera of this family are the following:

I. No internasal plates.

Urosteges one-rowed; anal entire ..... *Brachycranium* Hallow.

II. Internasals present.

Urosteges one-rowed; anal entire ..... *Atractaspis* Smith.

Urosteges more or less two-rowed; anal divided ..... * *Clothelaps* Cope.

The only genus in which the hemipenis is known is Brachycranium. Here the sulcus and entire organ are furcate, and spinous to near the extremity. The latter is furnished with wrinkled laminæ, which enclose a few irregular calyces at the apex, and below these are transverse farthest from the sulcus and longitudinal nearest to it. The spines are in longitudinal series. The only species examined (*B. corpulentum* Hallow.) is not deeply bifurcate, and the bifurcation of the sulcus corresponds with that of the organ (Pl. XXXII, Fig. 6).

Causidæ.

Subcaudals two-rowed; anal entire; scales keeled; rostral prominent, with recurved border. *Heterophis* Pet.

Subcaudal and anal plates double; scales keeled; rostral normal ..... *Causus* Wagl.

Subcaudals and anal entire; scales smooth; rostral normal; a loreal ..... *Dinodipsas* Pet.

Subcaudals two-rowed; anal entire; scales smooth; rostral normal; a loreal, and one nasal plate. *Azemiophis* Boul.

The only genus which I have been able to examine as to the penial structure is Causus. The sulcus and organ are deeply and equally bifurcate and the branches are extensively calyculate, while the median portions are spinous. The calyculate region is traversed by a deep groove, which is bound on one side by a longitudinal ala. The calyces are replaced in the groove by depressed laminæ, while the opposite side of the ala supports the usual structure. The borders of the calyces are serrate in the *C. rhombeatus* (Pl. XXXII, Fig. 7).

The characters are in general like those of the typical Solenoglypha.

Viperidæ.

I. Urosteges two-rowed.

a. Apex of hemipenis calyculate.

No flounces; calyces deeply fringed; nostril between two plates ..... *Vipera* Laur.

"Nostril between three plates" (Gthr.) ..... *Daboia* Gray.

* Type *Atractaspis hildebrandtii* Peters; second species, *A. congica* Peters.

No flounces; calyces moderately fringed; nostril surrounded by scales and a supranasal; no supraocular nor nasal horns..... *Bitis* Gray.

Flounced; spines below flounces; apex with calyces not fringed; nostril surrounded by scales and a supranasal, some of which are produced into horns..... *Clotho* Gray.

aa. Apex of hemipenis spinous.

Nostril surrounded by scales and a nasal; horn-like supraocular scales..... *Cerastes* Wagl.

II. Urosteges one-rowed.

Body and tail cylindric..... *Echis* Merr.

Body and tail compressed and prehensile..... *Atheris* Cope.

I am unacquainted with the penial structure of the last two genera.

Crotalidæ.

Two subfamilies are readily distinguishable, viz.:

No jointed caudal appendage..... *Cophiinæ.*

A jointed caudal appendage..... *Crotalinæ.*

COPHIINÆ.

β. Urosteges two-rowed.

Top of head scaled; urosteges four-rowed at end; a caudal spine..... *Lachesis* Wagl.

Top of head with small scales; tail normal..... **Cophias* Merr.

Top of head with large imbricate shield-like scales..... *Peltopelor* Gthr.

Top of muzzle scaled; rest of head shielded..... *Hypnale* Cope.

Top of head with nine shields; scales carinate..... *Trigonocephalus* Oppel.

Top of head with nine shields; scales smooth..... *Calloselasma* Cope.

ββ. Urosteges one-rowed.

Body and tail cylindric, not prehensile; head scaly..... *Bothriopsis* Pet.

Body and tail compressed, prehensile; head scaly, scales normal..... *Bothriechis* Pet.

As Bothriechis, but a horn-like produced scale over eye..... *Ophryacus* Cope.

Body and tail compressed, prehensile; head scaly; a row of scales outside the superciliary shield. *Teleuraspis* Cope.

Body and tail not prehensile; nine normal head-shields..... *Ancistrodon* Beauv.

The genera of the above series which I have examined are Cophias, Trigonocephalus, Ophryacus, Bothriopsis, Teleuraspis and Ancistrodon. In all, the hemipenis is calyculate, excepting in Ancistrodon; here it is flounced above the spinous region, with a tendency to form calyces next to the sulcus in *A. piscivorus.* In *Trigonocephalus* (*Halys*) *himalayanus* the calyces are not fringed and are restricted to the distal portion of each branch.

CROTALINÆ.

Only two genera of this subfamily are known.

Head with nine normal shields..... *Crotalophorus* Gray.

Head scaled above..... *Crotalus* Lim.

* Bothrops Wagl., Trimesurus Lacep. Peters.

In Crotalophorus the hemipenis is finely flounced, as in Ancistrodon, adding this point of resemblance to the possession of similar head-shields. In Crotalus the organ is strongly calyculate, the lower rows becoming flounces in *C. basiliscus* and *C. confluentus*, but not in *C. horridus*, *C. durissus* nor *C. molossus*. My statement that the spines are not ossified in the *C. durissus* was due to the fact that I examined a specimen not fully grown, although it was not a very small one. It is represented on Pl. XXXIII, Fig. 11.

EXPLANATION OF PLATES.

The figures, excepting Fig. 9 of Pl. XXIV, represent the hemipenis of a side split open so as to show the structures that are exhibited by the entire circumference. Each figure is therefore twice as wide as the organ in its normal condition. Where the organ is bifurcate, one branch only is split, the other being represented as invaginated, and with a portion of the retractor muscle continuous with its apex. The letters on the plates have the following significance :

Ss, sulcus spermaticus ; *cl*, calyculi or ruches ; *f*, flounces ; *sp*, spines ; *spl*, spinules ; *bh*, basal hook ; *p*, papillæ ; *l*, laminæ.

Plate XIV.

HEMIPENES OF DIFFERENT TYPES.

Fig. 1. *Ilysia scytale* L., Brazil. × 3.
Fig. 2. *Epicrates angulifer* D. & B., Cuba. × ⅔.
Fig. 3. *Charina bottæ* Blv., Oregon. × 3.
Fig. 4. *Holarchus ancorus* Gird., Philippine Ids. × 2.
Fig. 5. *Oligodon subquadratus* D. & B., Java. × 3.
Fig. 6. *Bascanium constrictor* L., N. America. × 2.
Fig. 7. *Opheomorphus alticolus* Cope, Peru. × 3.
Fig. 8. *Natrix fasciata sipedon* L., N. America. × 3.
Fig. 9. *Naja haje* L. *melanoleuca* Hall., W. Africa. × 2.
Fig. 10. *Bitis arietans* L., S. Africa. × 2.
Fig. 11. *Crotalus confluentus* Say, Texas. × 2.

Plate XV.

PEROPODA, ACROCHORDIDÆ, CALAMARINÆ.

Fig. 1. *Boa constrictor* L., Brazil. × ⅔.
Fig. 2. *Eunectes murinus* L., Brazil. × ⅔.
Fig. 3. *Chilobothrus striatus* Fisch., Hayti. × 2.
Fig. 4. *Enygrus bibronii* D. & B., Fejee Ids. × 2.
Fig. 5. *Lichanura trivirgata* Cope, Low. California. × 2.
Fig. 6. *Eryx jaculus* L., W. Asia. × 3.
Fig. 7. *Python spilotes* Lacep., Australia. × 3.
Fig. 8. *Ungualia melanura* D. & B., Cuba. × 4.
Fig. 9. *Calamaria gervaisii* D. & B., Philippine Ids. × 6.

Fig. 10. *Holarchus dolleyanus* Cope, Hainan. × 4.
Fig. 11. *Dicraulax purpurascens* Schl., Malaysia. × 4.
Fig. 12. *Pareas moellendorffii* Boetch., Hainan. × 3. Both branches split.
Fig. 13. *Acrochordus granulatus* Merr., Siam. × 3.

Plate XVI.

COLUBRINÆ.

Fig. 1. *Drymobius bifossatus* Raddi, Brazil. × 2.
Fig. 2. *Coluber flavescens* Laur., Italy. × 2.
Fig. 3. *Pityophis sayi* Schl., W. N. America. × 2.
Fig. 4. *Zamenis ravergieri* Menetr., Persia. × 2.
Fig. 5. *Zamenis korros* L., Siam. × 2.
Fig. 6. *Cynophis helenæ* Daud., Ceylon. × 3.
Fig. 7. *Spilotes sebastus* Cope, Surinam. × 2.

Plate XVII.

COLUBRINÆ.

Fig. 1. *Compsosoma corais* Cuv., Brazil. × 3.
Fig. 2. *Compsosoma virgatum* Schl., Asia. × 2.
Fig. 3. *Compsosoma pœcilostoma* Wied., Brazil. × $\frac{3}{2}$.
Fig. 4. *Gonyosoma oxycephalum* Reims, India. × 2.
Fig. 5. *Herpetodryas carinatus* Linn., Brazil. × 2.
Fig. 6. *Crossanthera melanotropis* Cope, Costa Rica. × 2.
Fig. 7. *Cyclophis modestus* Mart., W. Asia. × 4.
Fig, 8. *Contia mitis* B. & G., California. × 4.

Plate XVIII.

COLUBRINÆ.

Fig. 1. *Bascanium flagelliforme* Laur., Florida. × 3.
Fig. 2. *Drymobius reticulatus* Peters, Peru. × 3.
Fig. 3. *Drymobius boddœrtii* Seetz., Mexico. × 3.
Fig. 4. *Drymobius pulcherrimus* Cope, Nicaragua. × 4.
Fig. 5. *Zamenis hippocrepis* Linn., Italy. × 2.
Fig. 6. *Entechinus major* Gthr., China. × 4.
Fig. 7. *Salvadora bairdii* Jan., Mexico. × 4.
Fig. 8. *Macroprotodon cucullatus* D. & B., Algiers. × 4.
Fig. 9. *Geagras frontalis* Cope, Yucatan. × 3.
Fig. 10. *Ficimia olivacea* Gray, Mexico. × 4.
Fig. 11. *Chilomeniscus ephippicus* Cope, California. × 4.
Fig. 12. *Stylosoma extenuatum* Brown, Florida. × 3.
Fig. 13. *Hypsiglena ochrorhynchus* Cope, Texas. × 4.

Plate XIX.

COLUBRINÆ.

Fig. 1. *Drymobius margaritiferus* Schl., Mexico. × 3.
Fig. 2. *Cacocalyx percarinatus* Cope, Costa Rica. × 3.

Fig. 3. *Cyclophis aestivus* L., N. America. × 4.
Fig. 4. *Phyllorhynchus brownii* Stejn., Arizona. × 4.
Fig. 5. *Leptophis ahætulla* L., Brazil. × 3.
Fig. 6. *Leptophis præstans* Cope, Central America. × 3.
Fig. 7. *Thrasops flavigularis* Hallow., W. Africa. × 3.
Fig. 8. *Dendrophis picta* L., India. × 3.
Fig. 9. *Bucephalus capensis* Thunb., S. Africa. × 3.
Fig. 10. *Dasypeltis palmarum* Leach, W. Africa. × 4.
Fig. 11. *Cemophora coccinea* Blum., Florida. × 4.

Plate XX.

COLUBRINÆ.

Fig. 1. *Trimetopon pliolepis* Cope, Costa Rica. × 4.
Fig. 2. *Conopsis nasus* Gthr., Mexico. × 4.
Fig. 3. *Osceola elapsoidea* Holbr., Florida. × 4.
Fig. 4. *Osceola doliata triangulum* Boie, New York. × 4
Fig. 5. *Ophibolus rhombomaculatus* Holbr., D. Cal. × 2.
Fig. 6. *Ophibolus calligaster* Say, Kansas. × 3.
Fig. 7. *Ophibolus getulus* Linn., N. America. × 2.
Fig. 8. *Coronella girundica* Daud., Italy. × 3.
Fig. 9. *Proterodon tessellatus* Hallow., Japan. × 3.
Fig. 10. *Dianodon rufozonatus*, Cantor, China. × 3.
Fig. 11. *Symphimus leucostomus* Cope, Mexico. × 3.
Fig. 12. *Rhinochilus lecontei* B. & G., Texas. × 3.

Plate XXI.

COLUBRINÆ, NATRICINÆ.

Fig. 1. *Herpetodryas melas* Cope, Costa Rica. × 2.
Fig. 2. *Drymobius rhombifer* Gthr., Ecuador. × 4.
Fig. 3. *Coluber emoryi* B. & G., Texas. × 4.
Fig. 4. *Liopeltis vernalis* Harl., United States. × 4.
Fig. 5. *Acanthocalyx ventrimaculatus* Gray, W. Asia. × 4.
Fig. 6. *Tylanthera florulenta* Geoffr., W. Asia. × 4.
Fig. 7. *Contia episcopa* Kenn., Texas. × 4.
Fig. 8. *Ophibolus californiæ* DeBlv., Lower California. × 2.
Fig. 9. *Adelphicus quadrivirgatus* Jan., Centr. America. × 3.
Fig. 10. *Ablabes baliodirus* Boie, Malaysia. × 4.
Fig. 11. *Eutænia multimaculata* Cope, Chihuahua. × 4.

Plate XXII.

NATRICINÆ.

Owing to the position of the basal section the basal hook was in some cases lost.

Fig. 1. *Natrix rhombifera* Hallow., Texas. × 3.
Fig. 2. *Natrix vulgaris* Laur., Italy. × 4.
Fig. 3. *Eutænia sirtalis* L., N. America. × 4.
Fig. 4. *Eutænia melanogaster* Wiegm., Mexico. × 4.
Fig. 5. *Natrix kirtlandii* Kenn., N. America. × 4.
Fig. 6. *Bothrodytes ceylonensis* Gthr., Ceylon. × 4.

Fig. 7. *Bothrodytes tigrinus* Boie, Japan. × 4.
Fig. 8. *Bothrodytes piscator* Schneid., India. × 4.
Fig. 9. *Bothrodytes spilogaster* Boie, Java. × 4.
Fig. 10. *Storeria dekayi* Storer, N. America. × 4.
Fig. 11. *Storeria occipitomaculata* Holbr., N. America. × 4.
Fig. 12. *Tropidoclonium lineatum* Hallow., Texas. × 4.

Plate XXIII.

NATRICINÆ AND HOMALOPSINÆ.

Fig. 1. *Eutænia proxima* Say, Texas. × 4.
Fig. 2. *Natrix septemvittata* Say, Pennsylvania. × 4.
Fig. 3. *Natrix grahamii* B. & G., Texas. × 4.
Fig. 4. *Natrix hydrus* Pallas, S. Europe. × 4.
Fig. 5. *Natrix viperina* Merr., Italy. × 4.
Fig. 6. *Natrix stolata* L., Hainan, China. × 4.
Fig. 7. *Natrix storerioides* Cope, Mexico. × 4.
Fig. 8. *Liodytes allenii* Garman, Florida. × 4.
Fig. 9. *Virginia valeriæ* B. & G., Texas. × 4.
Fig. 10. *Haldea striatula* L., Texas. × 4.
Fig. 11. *Ceratophallus vittatus* L., Java. × 3.
Fig. 12. *Herpeton tentaculatum* Lacep., Siam. × 4.
Fig. 13. *Homalopsis buccata* L., Siam. × 3.
Fig. 14. *Cerberus rhynchops* Schn., India. × 3.
Fig. 15. *Cantoria elapiformis* Peters, Siam. × 3.

Plate XXIV

LYCODONTINÆ.

Fig. 1. *Lycodon aulicus* L., India. × 4.
Fig. 2. *Anoplophallus maculatus* Hallow. × 3.
Fig. 3. *Boaodon virgatus* Hallow., West Africa. × 3.
Fig. 4. *Boaodon infernalis* Gthr., S. Africa. × 3.
Fig. 5. *Lamprophis inornatus* D. & B., S. Africa. × 3.
Fig. 6. *Lycophidium laterale* Hallow., W. Africa. × 3.
Fig. 7. *Elapops modestus* Gthr., W. Africa. × 4.
Fig. 8. *Dromicodryas bernierii* D. & B., Madagascar. × 4.
Fig. 9. *Pseudaspis cana* L., South Africa; the hemipenis in natural erection and not split, one-half not fully evaginated; from the outside; *a* from above. × 2.
Fig. 10. *Homalosoma lutrix* L., S. Africa. × 4.
Fig. 11. *Anomalodon madagascariensis* D. & B., Madagascar. × 3.

Plate XXV.

DROMICINÆ.

Fig. 1. *Hypsirhynchus ferox* Gthr., Hayti. × 3.
Fig. 2. *Dromicus parvifrons* Cope, Hayti. × 4.
Fig. 3. *Ocyophis ater* Gosse, Jamaica. × 2.
Fig. 4. *Alsophis angulifer* D. & B., Cuba. × 2.
Fig. 5. *Farancia abacura* Holbr., Louisiana. × 2.

Fig. 6. *Carphophiops amoena* Say, N. America. × 4.
Fig. 7. *Echinanthera cyanopleura* Cope, S. Brazil. × 4.
Fig. 8. *Rhadinæa decorata* Gthr., Mexico. × 4.
Fig. 9. *Pliocercus elapoides* Cope, Mexico. × 4.
Fig. 10. *Ninia atrata* Hallow., Mexico. × 4.
Fig. 11. *Tretanorhinus variabilis* D. & B., Cuba. × 3.
Fig. 12. *Abastor erythrogrammus* Daud., Georgia, N. Amer. × 2,

LEPTOGNATHINÆ.

Fig. 13. *Petalognathus nebulata* L., Costa Rica. × 4.

Plate XXVI.

XENODONTINÆ.

Fig. 1. *Aporophis anomalus* Günth., Paraguay. × 3.
Fig. 2. *Xenodon almadensis* Wagl., Brazil. × 3.
Fig. 3. *Opheomorphus typhlus* L., Brazil. × 3.
Fig. 4. " *cobella* L., Brazil. × 4.
Fig. 5. *Xenodon severus* L., Brazil. × 4.
Fig. 6. *Lystrophis orbignyi* D. & B., S. Brazil. × 3.

DROMICINÆ.

Fig. 7. *Pseudoeryx plicatilis* Linn., Brazil. × 2.
Fig. 8. *Helicops fumigatus* Cope, Brazil. × 3.
Fig. 9. *Rhabdosoma badium* Boie, Upper Amazon. × 4.
Fig. 10. " *elaps* Gthr., Upper Amazon. × 3.
Fig. 11. *Acanthophallus colubrinus* Günth., Brazil. × 4.
Fig. 12. *Uromacer oxyrhynchus* D. & B., Hayti. × 3.
Fig. 13. *Amastridium veliferum* Cope, Panama. × 4.
Fig. 14. *Diadophis regalis* B. & G., Arizona. × 4.

Plate XXVII.

XENODONTINÆ.

Fig. 1. *Xenodon reginæ* L. var. Venezuela. × 3.
Fig. 2. *Opheomorphus brachyurus* Cope, Brazil. × 4.

DROMICINÆ.

Fig. 3. *Hydrops martii* Spix., Brazil. × 4.
Fig. 4. *Taeniophallus nicagus* Cope, Brazil. × 4.
Fig. 5. *Monobothris chamissonis* Wiegm., Peru. × 3.
Fig. 6. *Rhadinæa flavilatus* Cope, Florida. × 3.

SCYTALINÆ.

Fig. 7. *Hydrocalamus quinquevittatus* D. & B., Mexico. × 3.
Fig. 8. *Philodryas viridissimus* L., Brazil. × 4.
Fig. 9. *Thamnodynastes strigatus* Gthr., S. Brazil. × 3.
Fig. 10. *Thamnodynastes nattererii* Mik., S. Brazil. × 4.
Fig. 11. *Tachymenis peruvianus* Wiegm., Peru. × 3.
Fig. 12. *Tomodon ocellatus* D. & B., Uruguay. × 4.
Fig. 13. *Rhinostoma nasuum* Wagl., S. Amer. × 3.

Fig. 14. *Scytale coronatum* Schneid., S. Amer. × 4.
Fig. 15. *Langaha nasuta* Shaw, Madagascar. × 3.
Fig. 16. *Grayia smythii* Leach, W. Africa. × 2.

Plate XXVIII.

ERYTHROLAMPRINÆ AND SCYTALINÆ.

Fig. 1. *Erythrolamprus venustissimus* Boie, Brazil. × 3.
Fig. 2. *Conophis lineatus* D. & B., Mexico. × 3.
Fig. 3. *Jaltris dorsalis* Gthr., Hayti. × 2.
Fig. 4. *Oxyrrhopus plumbeus* Wied., Brazil. × 3.
Fig. 5. *Oxyrrhopus petalarius* L., Brazil. × 3.
Fig. 6. *Philodryas nattererii* Steind., Paraguay. × 2.
Fig. 7. *Philodryas schottii* Fitz., Paraguay. × 2.
Fig. 8. *Coniophanes fissidens* Gthr., Centr. America. × 4.

Plate XXIX.

DROMICINÆ, LEPTOGNATHINÆ, ERYTHROLAMPRINÆ AND DIPSADINÆ.

Fig. 1. *Heterodon nasicus* B. & G., Dakota. × 3.
Fig. 2. *Heterodon platyrhinus* Latr., N. America. × 2.
Fig. 3. *Mesopeltis sanniolus* Cope, Yucatan. × 4.
Fig. 4. *Leptognathus anthracops* Cope, Nicaragua. × 4.
Fig. 5. *Tantilla rubra* Cope, Mexico. × 4.
Fig. 6. *Elapomorphus michoacanensis* Dug., Mexico. × 4.
Fig. 7. *Uriechis microlepidotus* Gthr., Natal. × 3.
Fig. 8. *Stenorhina ventralis* D. & B., Mexico. × 3.
Fig. 9. *Dipsadomorphus trigonatus* Schn., Malacca. × 3.
Fig. 10. *Psammodynastes pulverulentus* Boie, Tonquin. × 4.
Fig. 11. *Dryophis fulgidus* Daud., Centr. America. × 3.
Fig. 12. *Lygophis elegans* Tsch., Peru. × 2. Letter *p*, apical disc; p^1, same in profile, enlarged.

Plate XXX.

DIPSADINÆ.

Fig. 1. *Dipsadomorphus fuscus* Gray, Australia. × 3.
Fig. 2. *Dipsas dendrophila* Reinwt., Java. × 2.
Fig. 3. *Himantodes gemmistratus* Cope, W. Mexico. × 4.
Fig. 4. *Rhinobothryum lentiginosum* Scop., Brazil. × 3.
Fig. 5. *Sibon septentrionale* Kenn., Mexico. × 4.
Fig. 6. *Sibon nigrofasciatum* Gthr., Nicaragua. × 4.
Fig. 7. *Trimorphodon biscutatus* D. & B., Mexico. × 2.
Fig. 8. *Crotaphopeltis rufescens* Gm., Africa. × 2.
Fig. 9. *Chrysopelea ornata* Shaw, India. × 2.
Fig. 10. *Procinura æmula* Cope, Mexico. × 3.
Fig. 11. *Scolecophis atrocinctus* D. & B., Centr. America. × 4.
Fig. 12. *Tantilla melanocephala* Schl., Brazil. × 4.
Fig. 13. *Pogonaspis ruficeps* Cope, Costa Rica. × 4.
Fig. 14. *Cladophis kirtlandii* Hallow., W. Africa. × 4.
Fig. 15. *Tragops laetus* Cope, Farther India. × 4.
Fig. 16. *Oxybelis acuminata* Wied., Centr. America. × 4.

Plate XXXI.

PROTEROGLYPHA AND PLATYCERCA.

Fig. 1. *Dendraspis jamesonii* Traill (*Dinophis hammondii* Hallow.), W Africa. × 3.
Fig. 2. *Acanthophis antarctica* Shaw, Australia. × 3.
Fig. 3. *Sepedon hæmachates* Merr., S. Africa. × 3
Fig. 4. *Bungarus semifasciatus* Kuhl, India. × 3.
Fig. 5. *Adeniophis bivirgatus* Schl., Siam. × 4.
Fig. 6. *Hoplocephalus coronatus* Schl., Australia. × 4.
Fig. 7. *Elaps corallinus* L., Central America. × 3.
Fig. 8. *Elaps surinamensis* Cuv., Brazil. × 3.
Fig. 9. *Vermicella annulata* Gray, Australia. × 4.
Fig. 10. *Hydrophis hardwickii* Gray, Siam. × 3.

Plate XXXII.

PROTEROGLYPHA, PLATYCERCA, SOLENOGLYPHA.

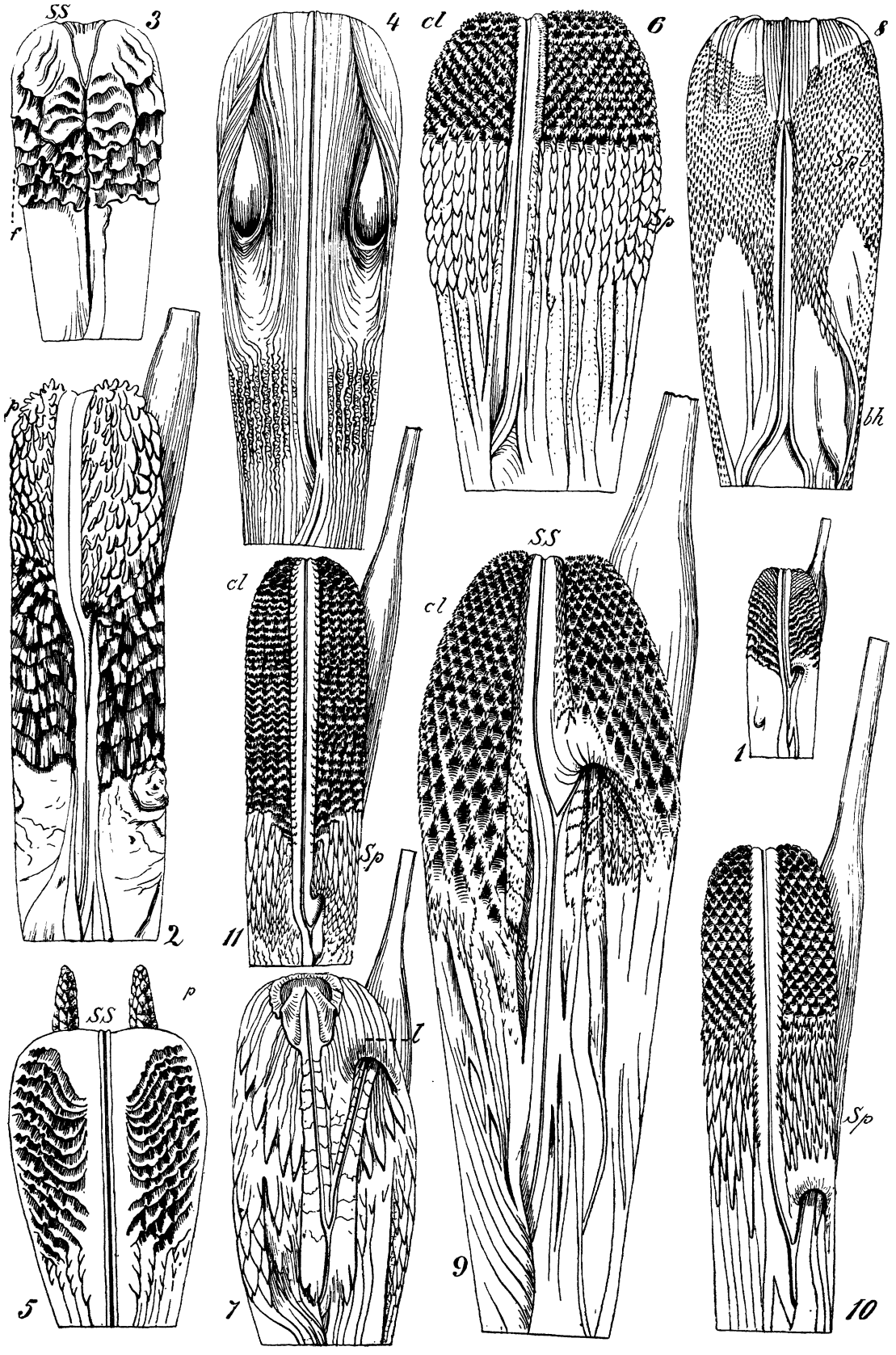
Fig. 1. *Diemenia annulata* Buch. & Pet., W. Africa. × 2.
Fig. 2. *Ophiophagus bungarus* Schl., Malacca. × 1.
Fig. 3. *Elaps imperator* Cope, Ecuador. × 4.
Fig. 4. *Hydrophis stokesii* Gray, Singapore. × $\frac{3}{2}$.
Fig. 5. *Hydrus bicolor* Shaw, Pacific Ocean. × 3.
Fig. 6. *Brachycranium corpulentum* Hallow., W. Africa. × 4.
Fig. 7. *Causus rhombeatus* Licht., Centr. Africa. × 3.
Fig. 8. *Cophias atrox* L., Nicaragua. × 3.
Fig. 9. *Bothriopsis affinis* Boc., Mexico. × 4.
Fig. 10. *Crotalus molossus* B. & G., Arizona. × 4.

Plate XXXIII.

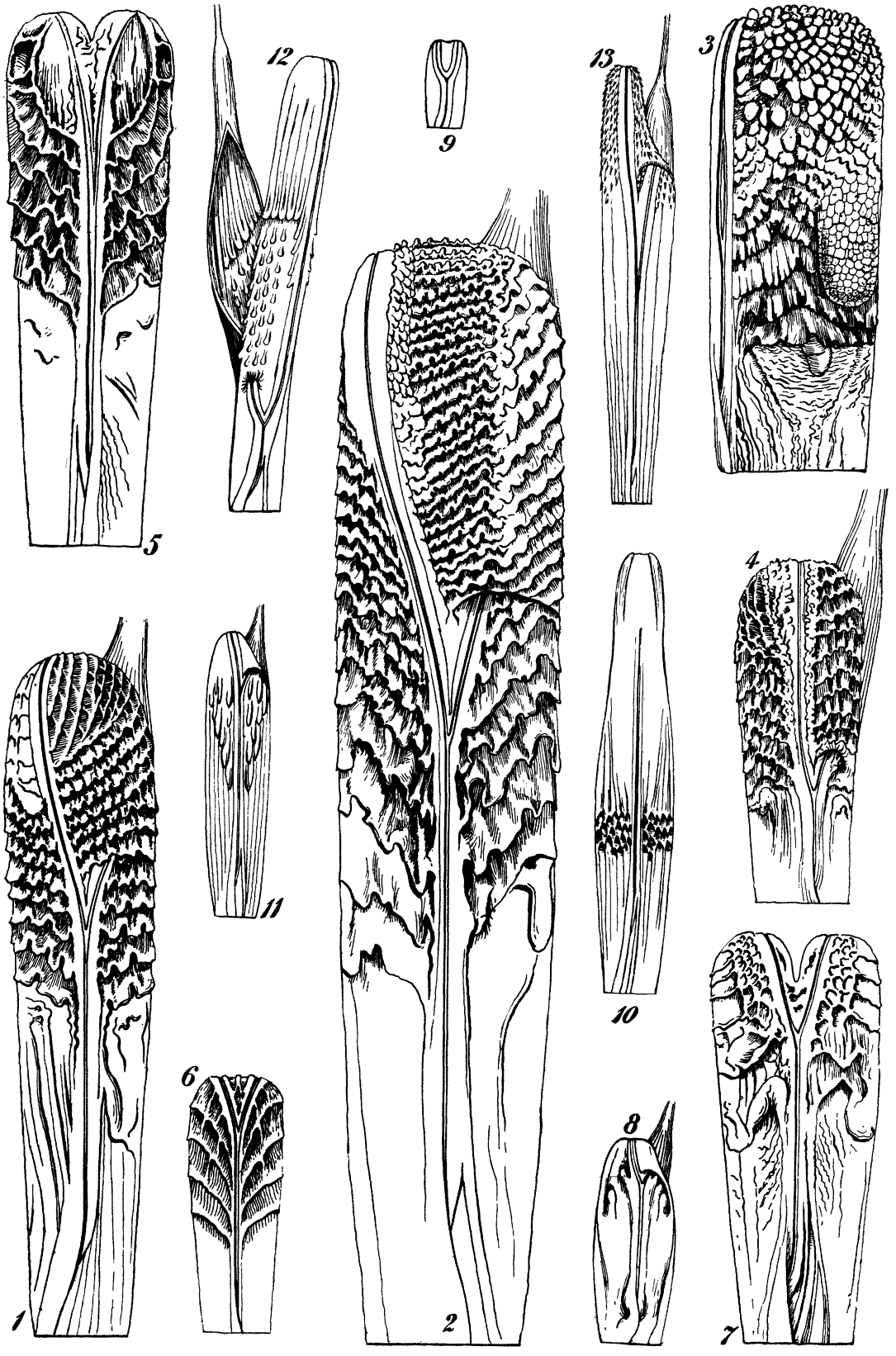
SOLENOGLYPHA.

Fig. 1. *Clotho rhinocerus* Schl., Gaboon. × $\frac{3}{2}$.
Fig. 2. *Vipera aspis* L., Italy. × 3.
Fig. 3. *Cerastes ægyptiacus* L. × 2.
Fig. 4. *Ancistrodon contortrix* L., New York. × 3.
Fig. 5. *Ancistrodon piscivorus* L., Florida. × 2.
Fig. 6. *Cophias alternatus* D. & B., Brazil. × 2.
Fig. 7. *Ophryacus undulatus* Jan., Mexico. × 2.
Fig. 8. *Crotalophorus catenatus* Raf., Michigan. × 3.
Fig. 9. *Crotalus horridus* L., Pennsylvania. × 2.
Fig. 10. *Crotalus basiliscus* Cope, Mexico. × 2.
Fig. 11. *Crotalus durissus* L., Brazil ; young. × 3.

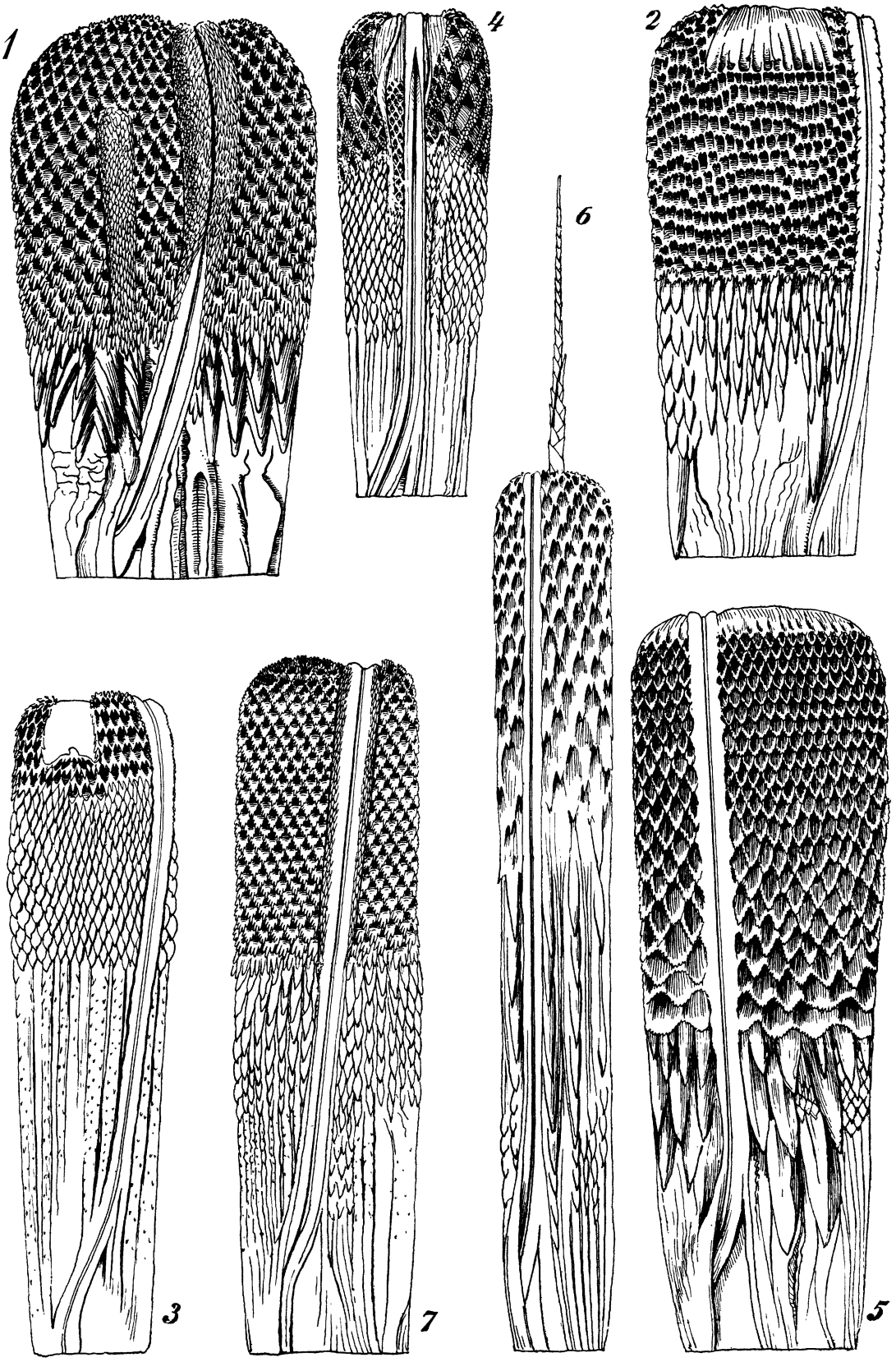
NOTE.—The *Anoplophallus maculatus* Hallow., of the preceding pages is the *Ophites subcinctus* of Boie. There are no hypapophyses on the posterior dorsal vertebræ ; hence the species must be arranged with Lycodon, from which it differs in penial characters.



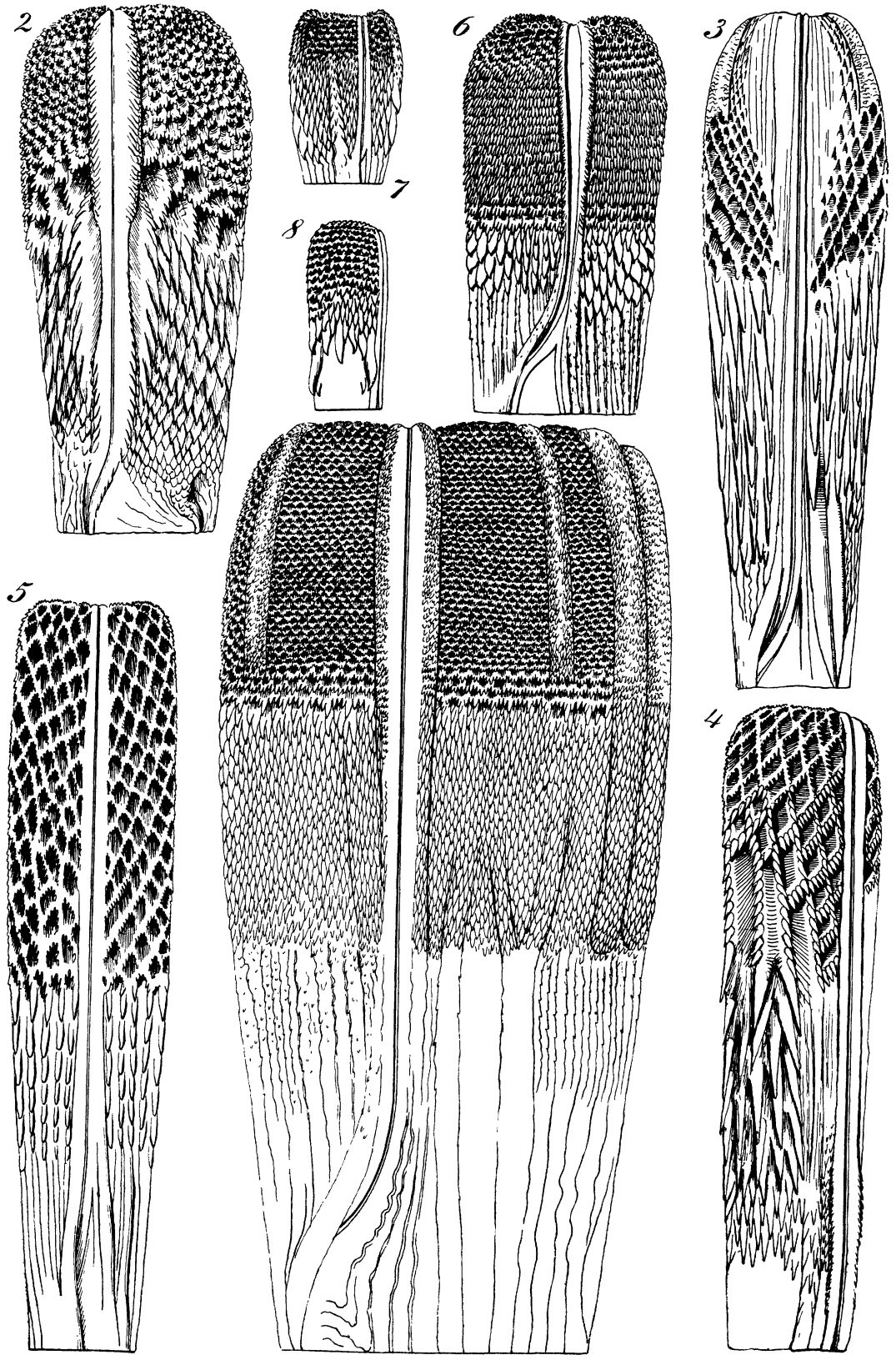
Representative types.



Tortricina. Peropoda. Calamariinæ.



Colubrinæ.



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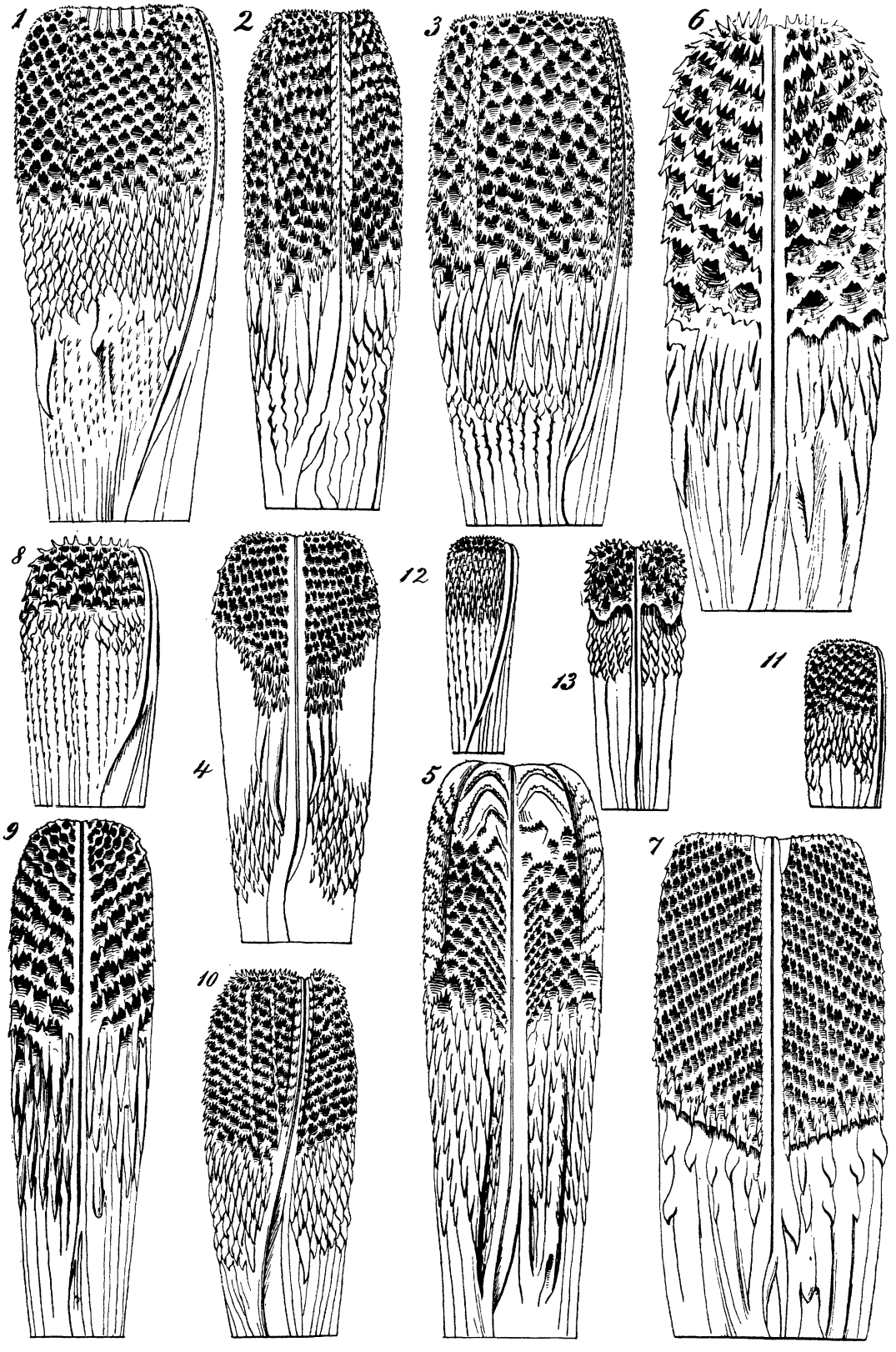

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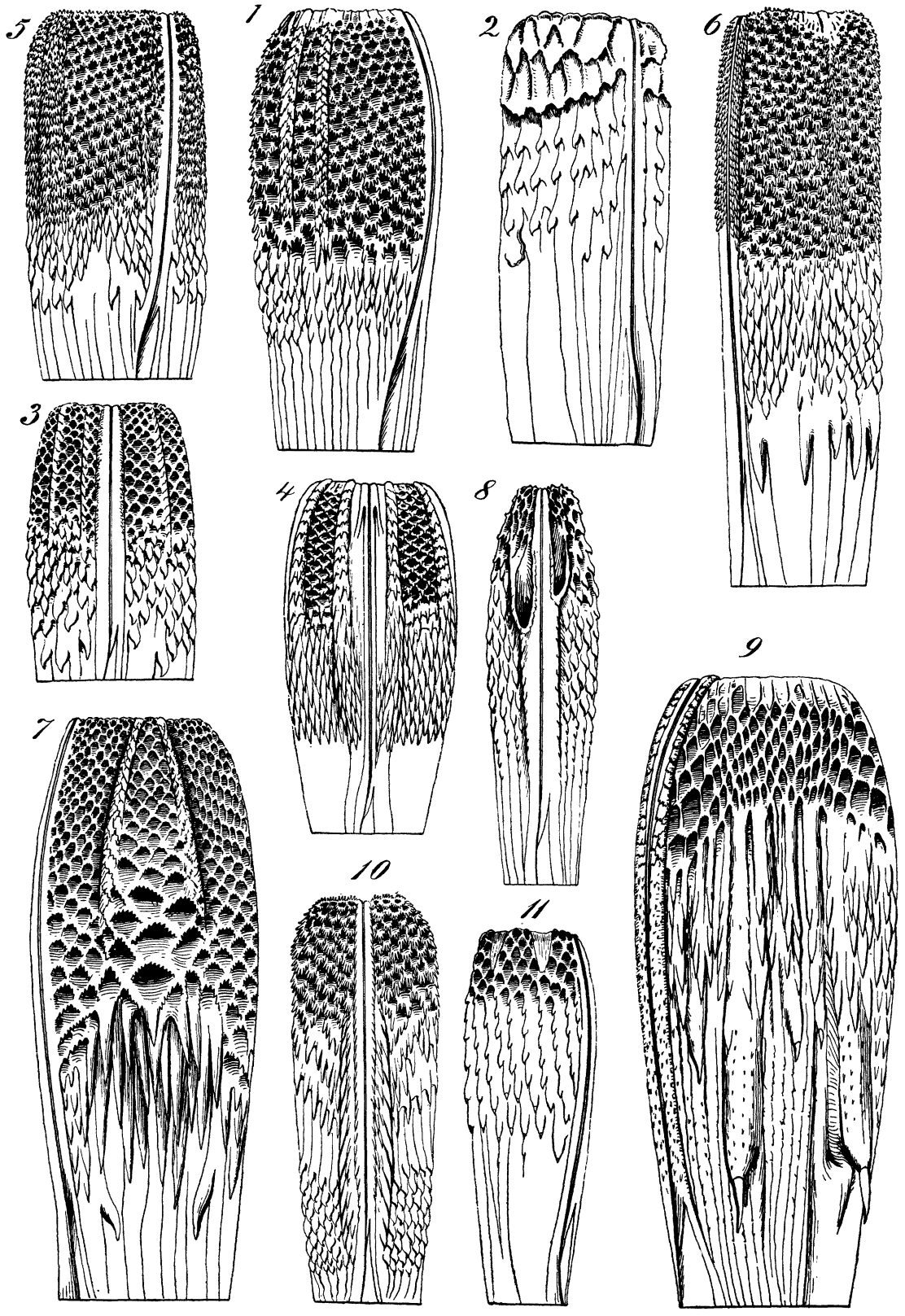

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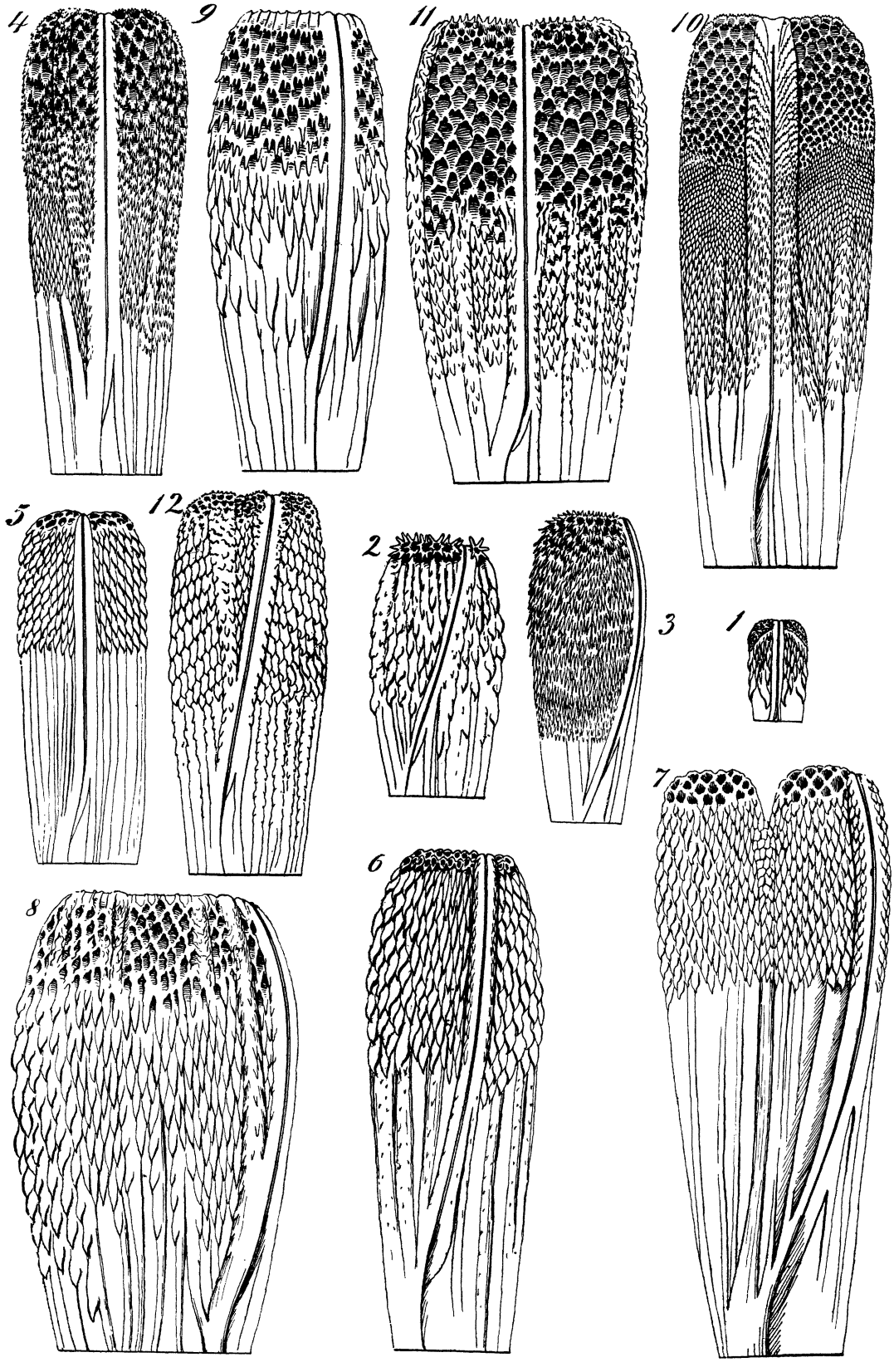

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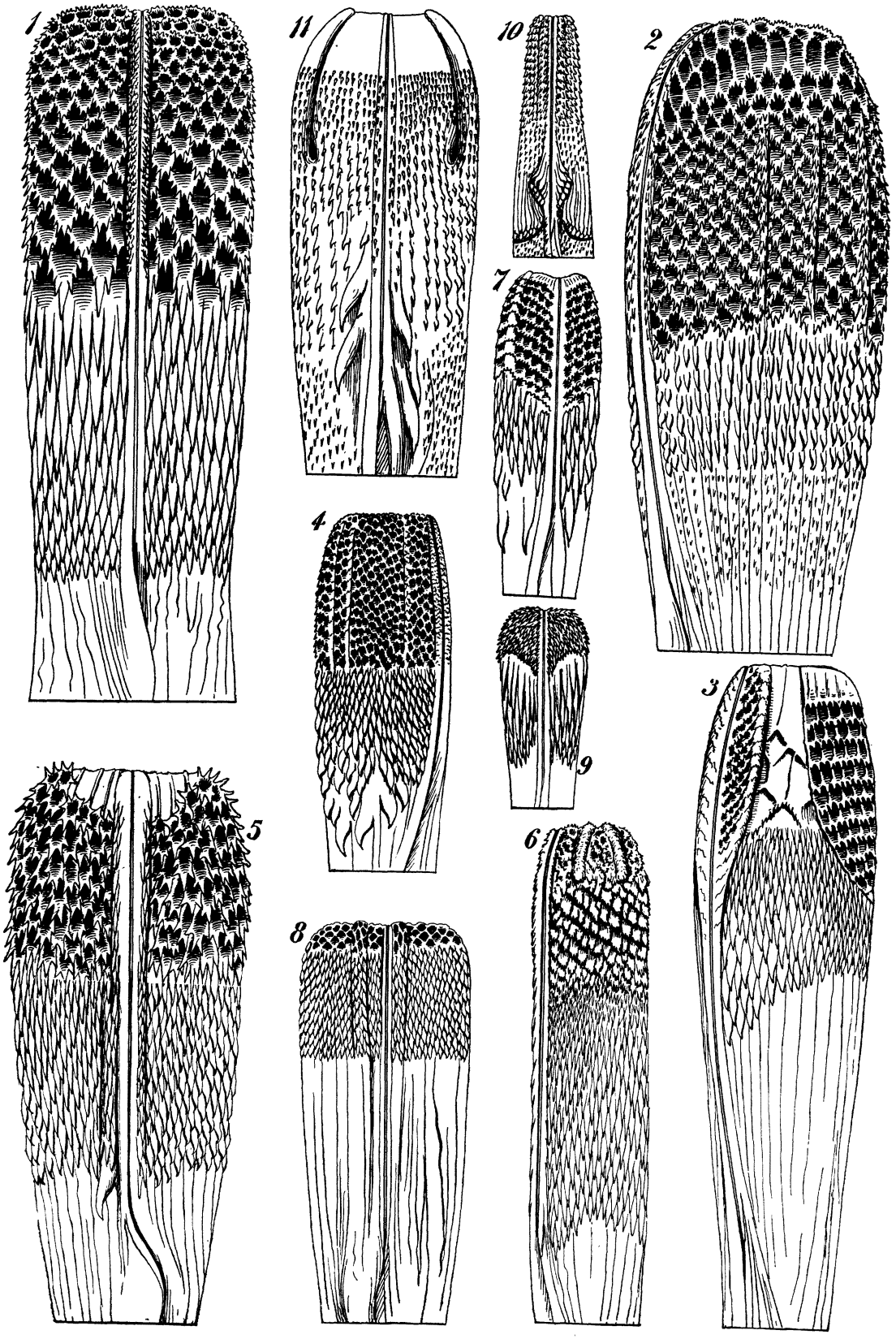
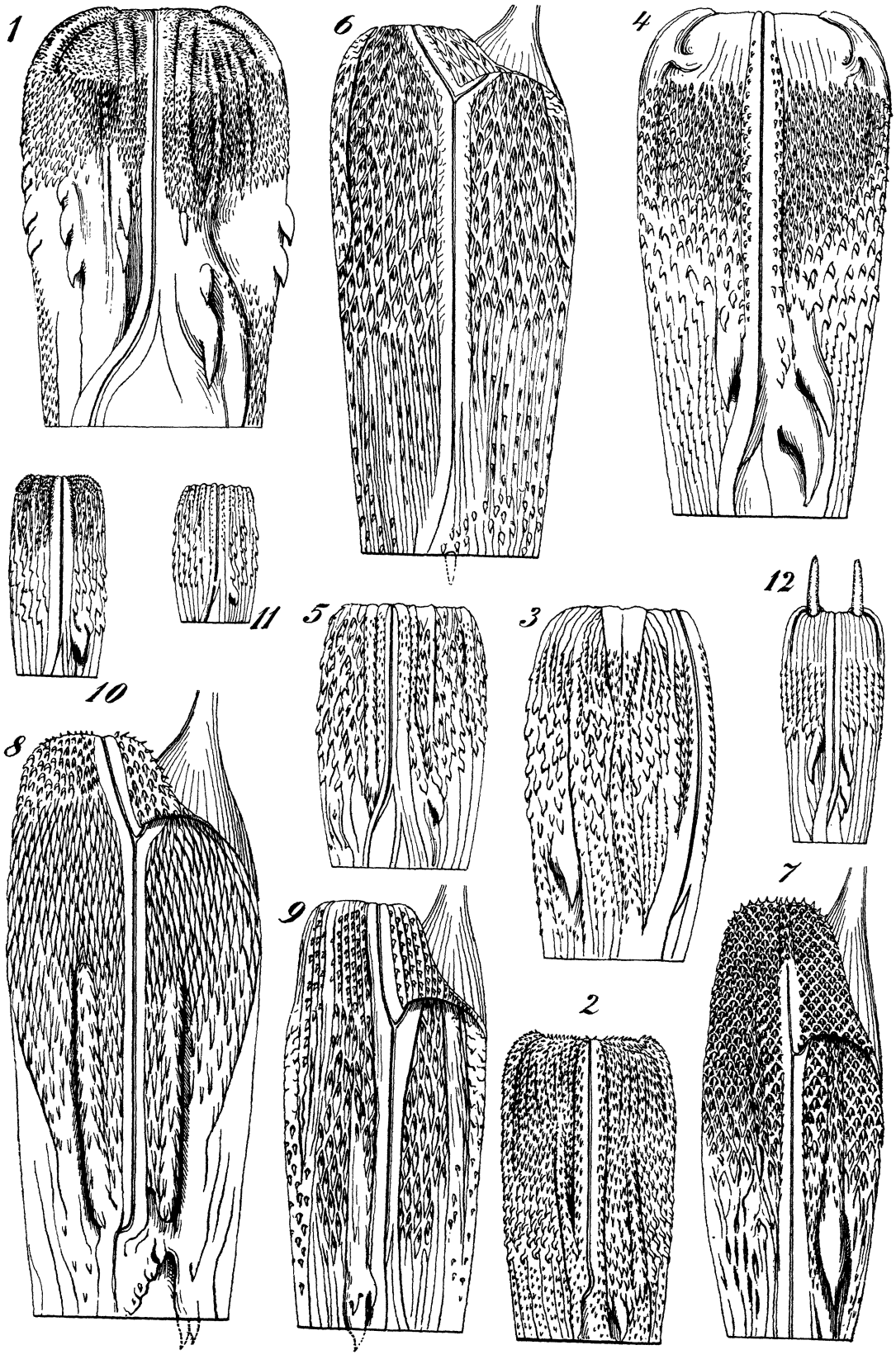
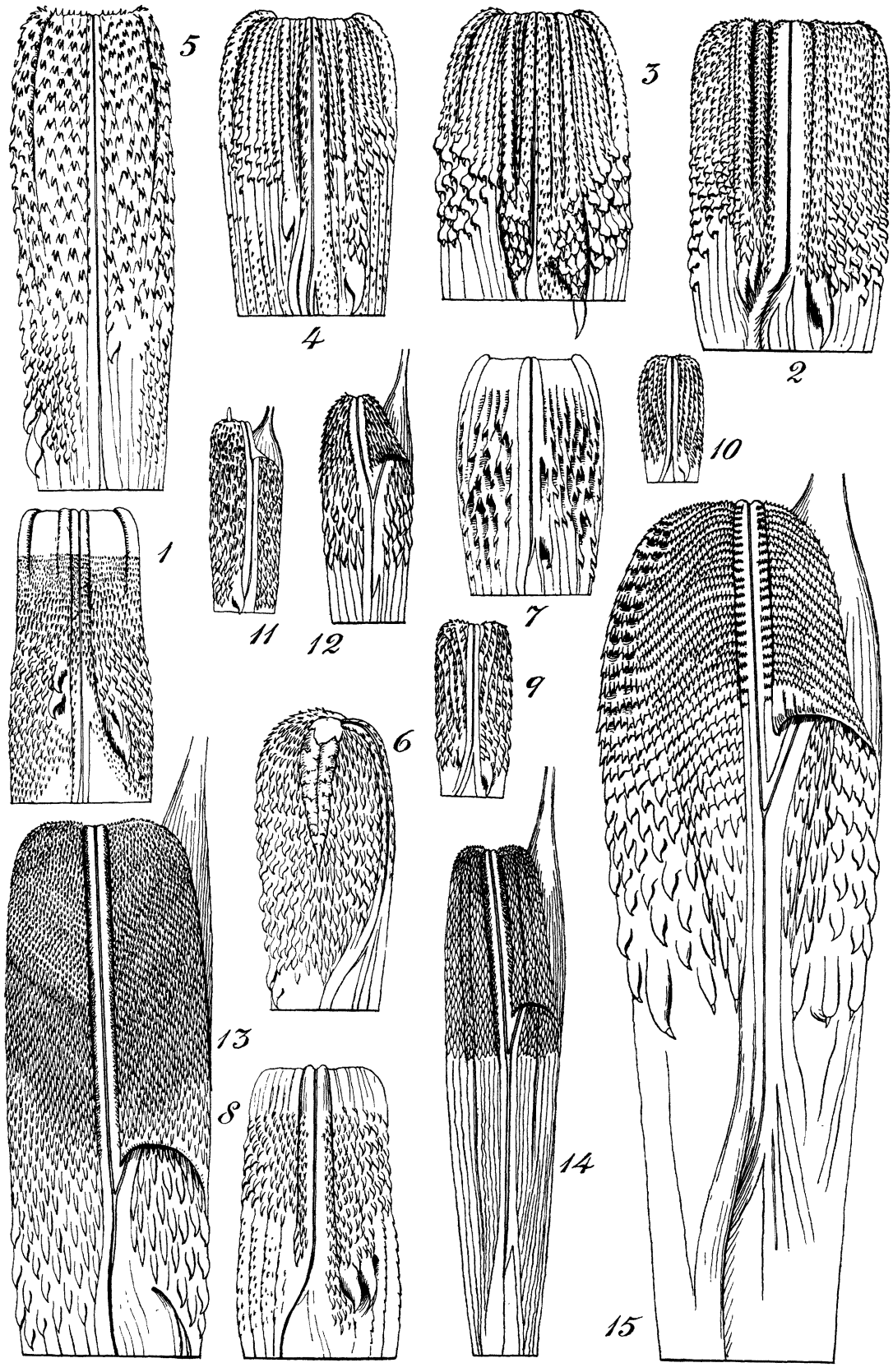


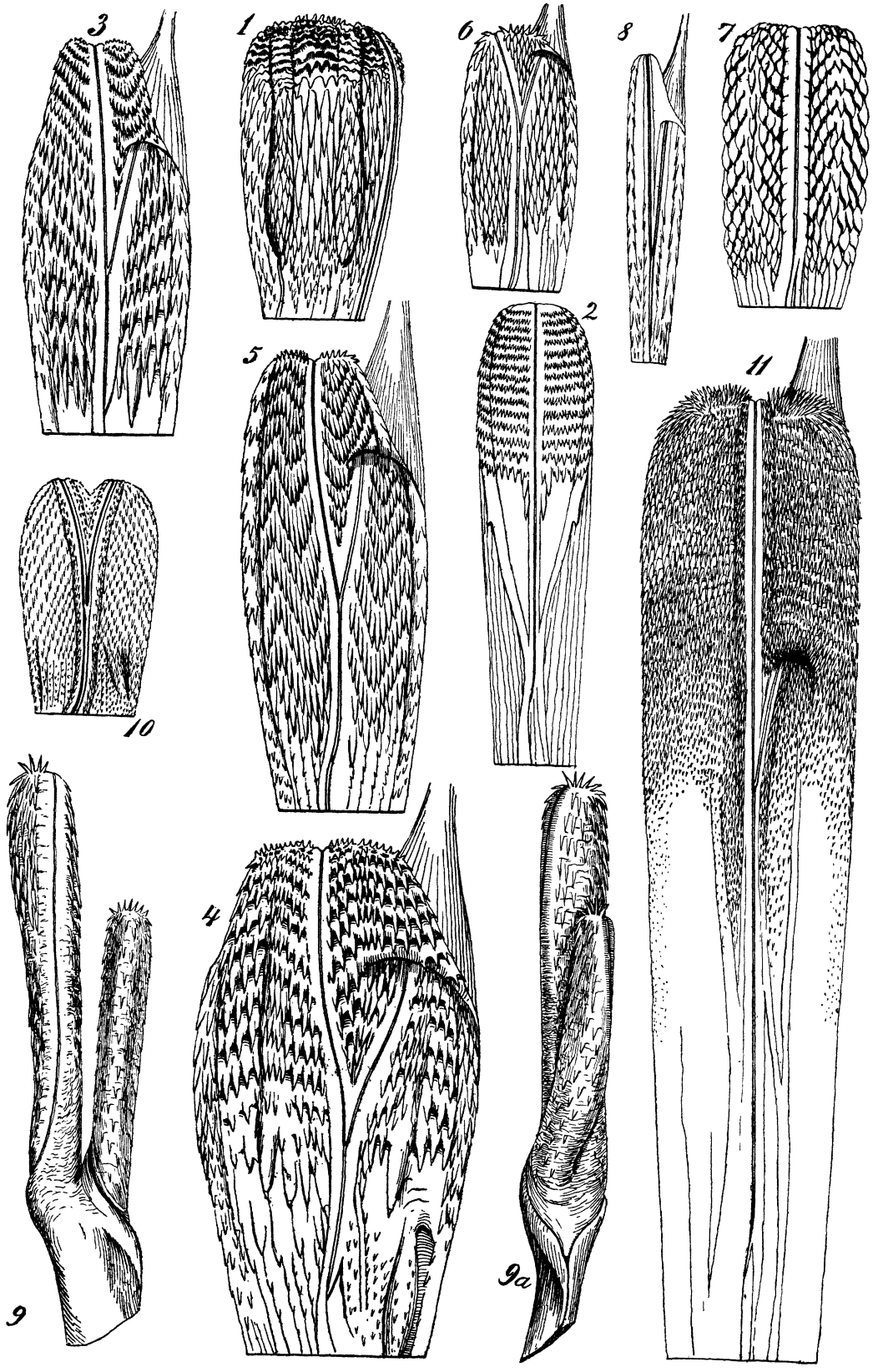
Colubrinæ. Natricinæ.



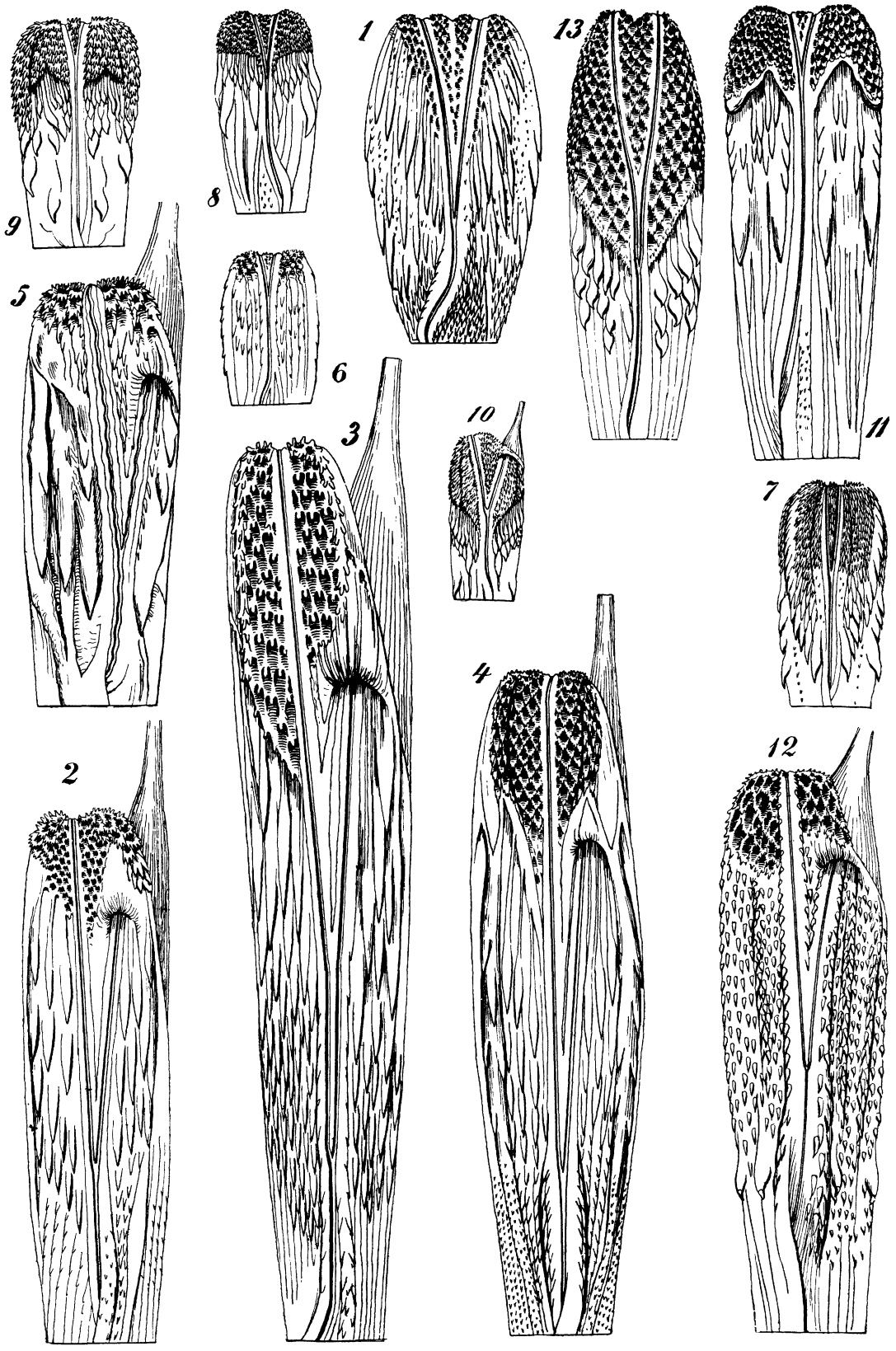
Natricinæ.



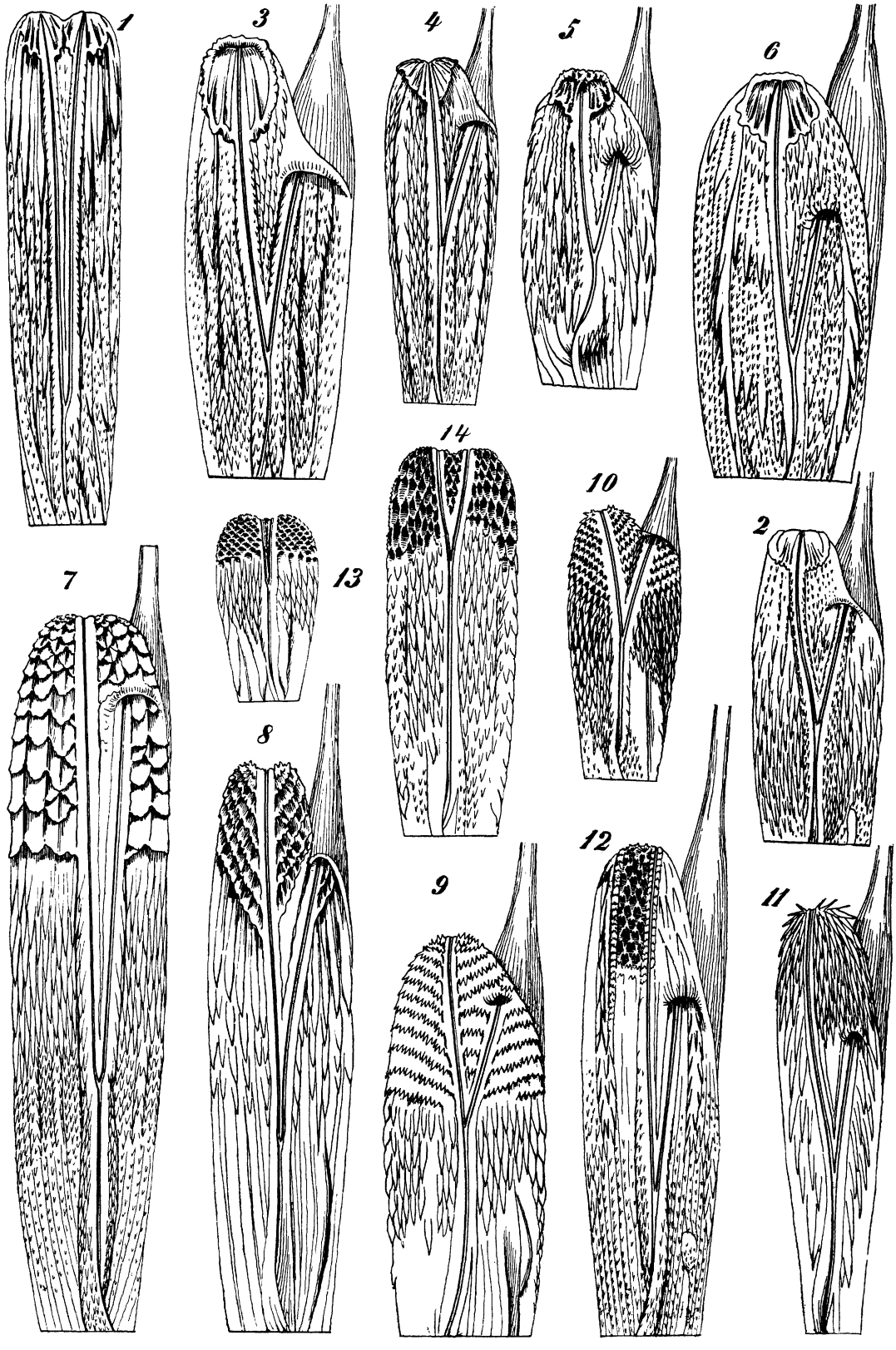
Natricinæ. Homalopsinæ.



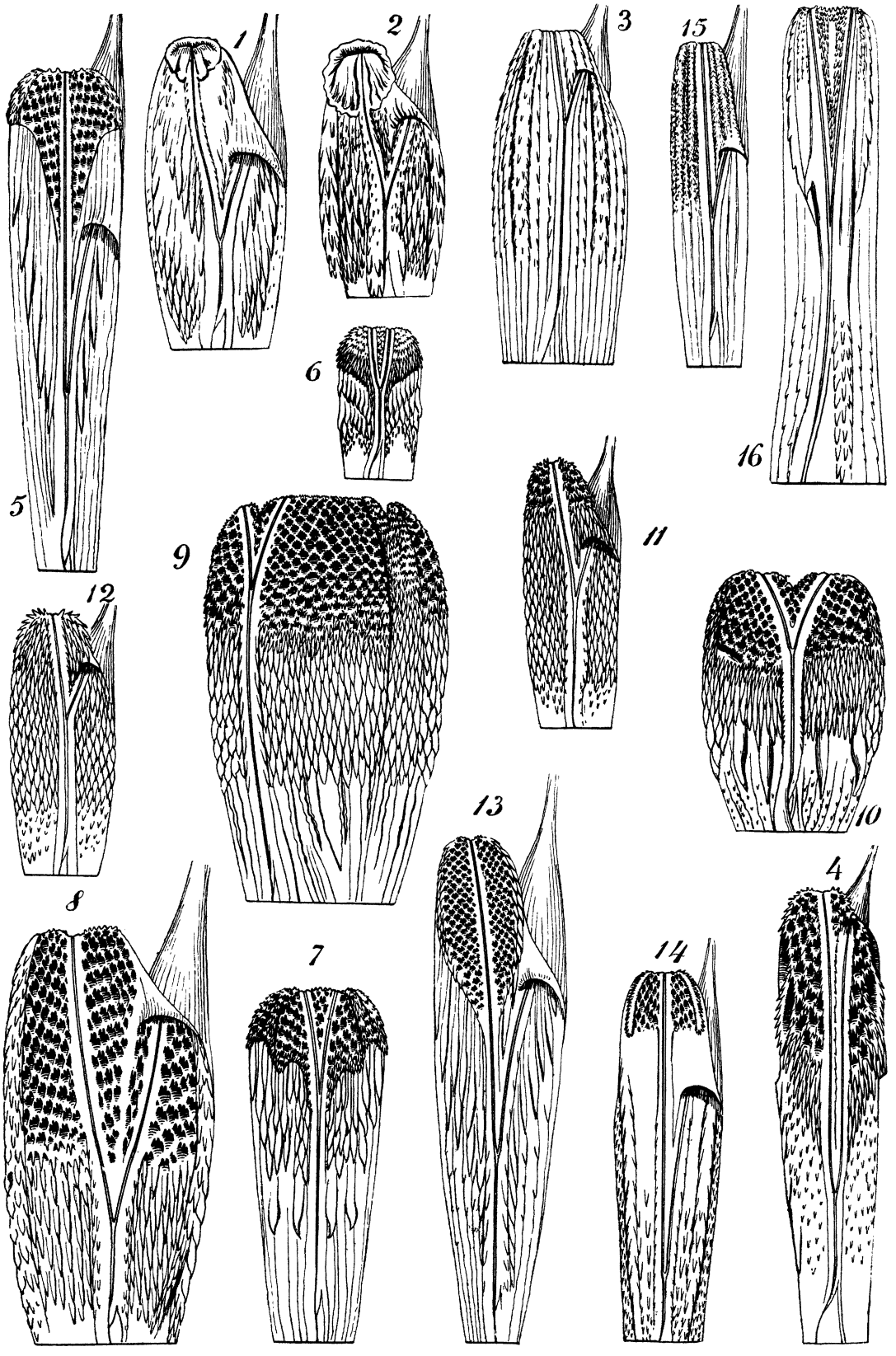
Lycodontinæ.



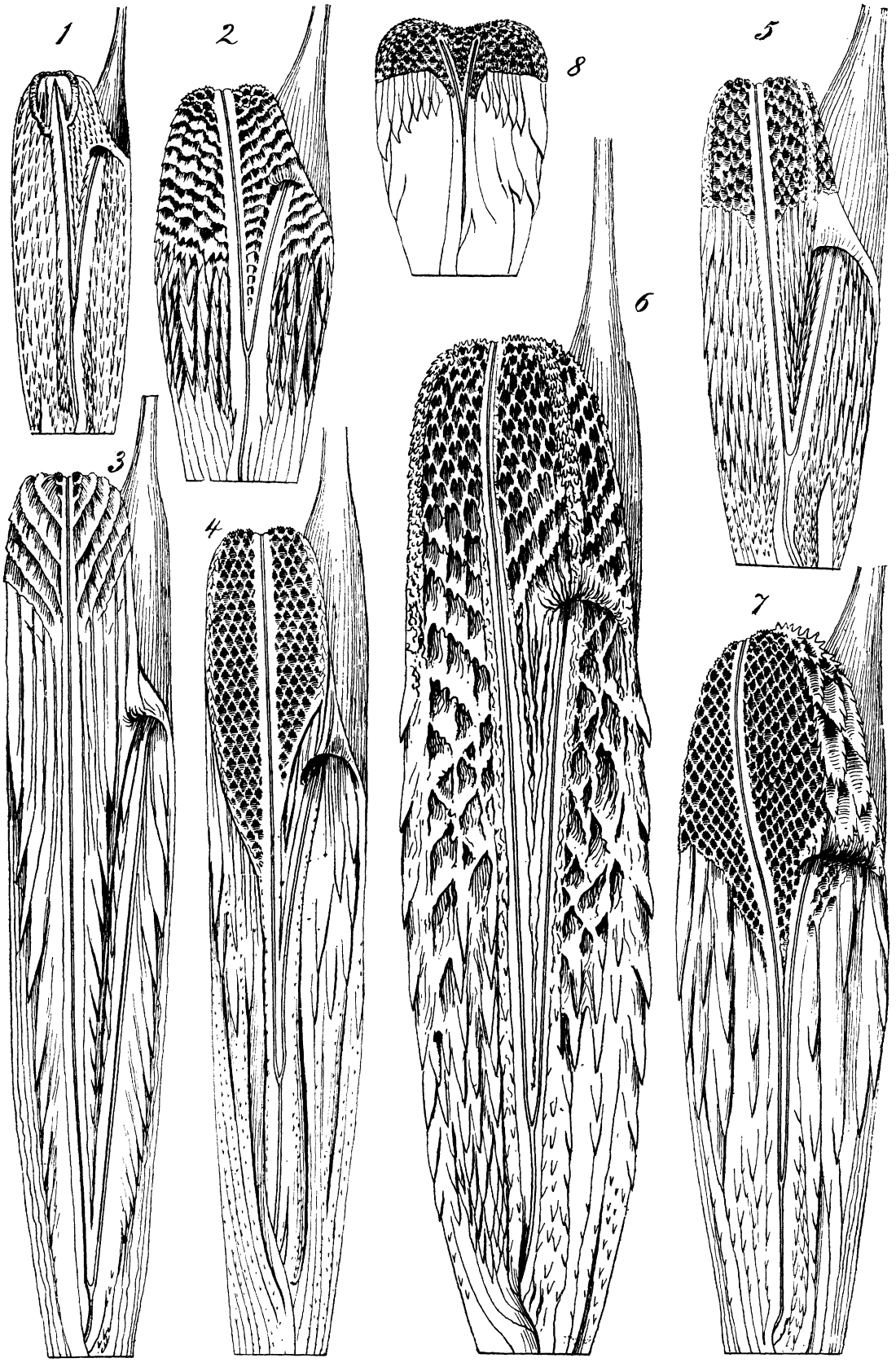
Dromicinæ. Leptognathinæ.



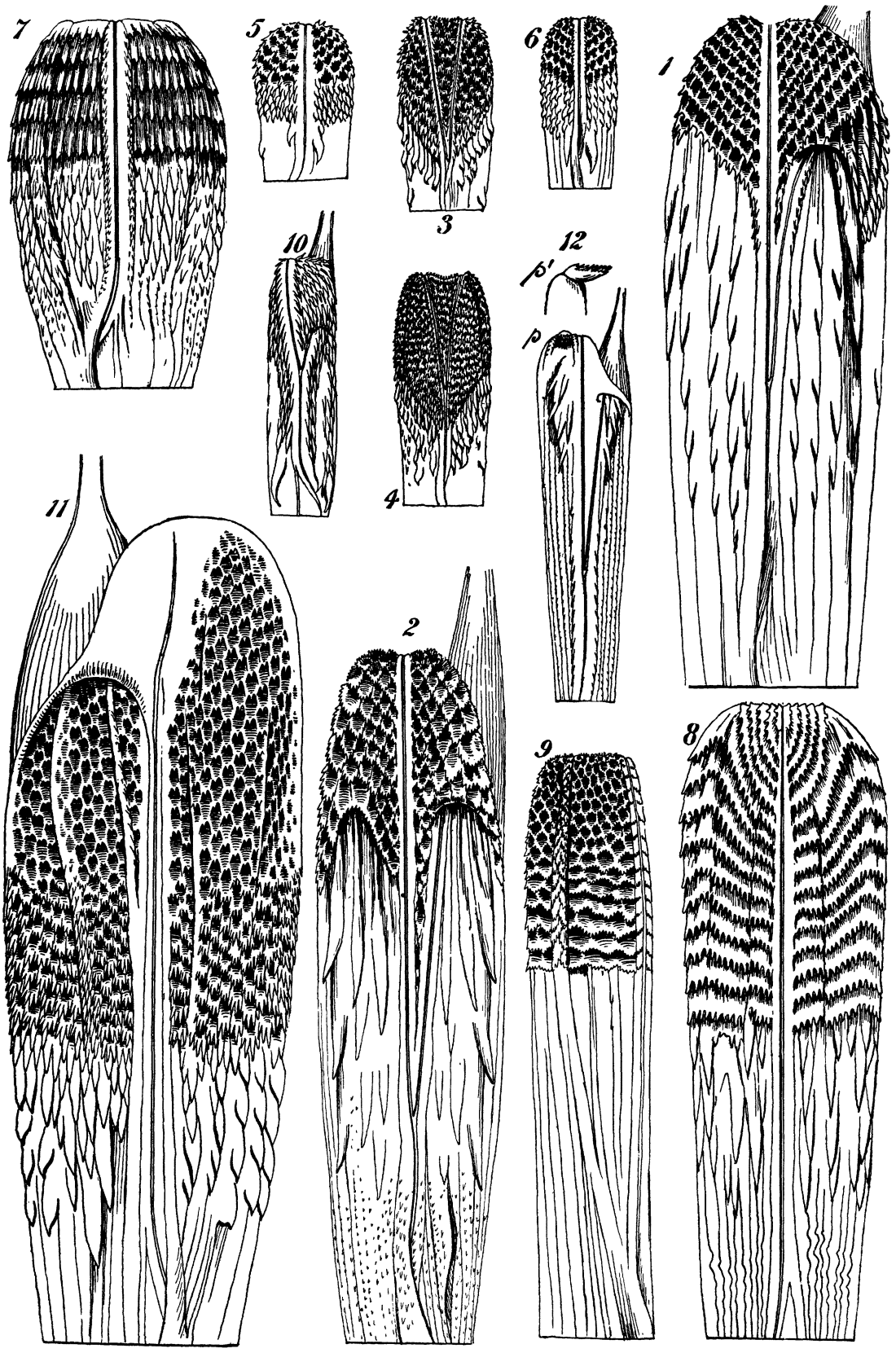
Xenodontinæ. Dromicinæ.



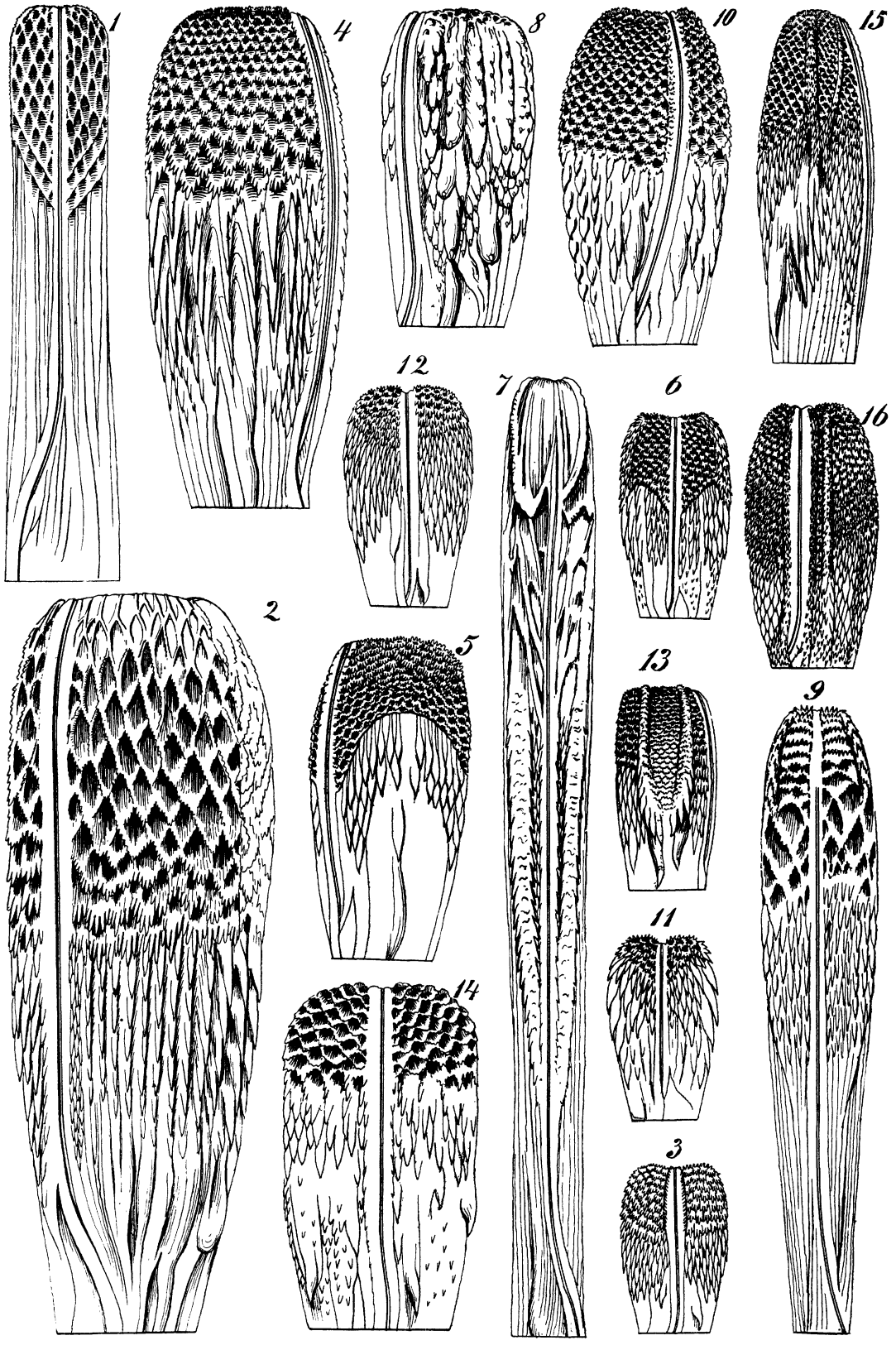
Xenodontinæ. Dromicinæ. Scytalinæ.



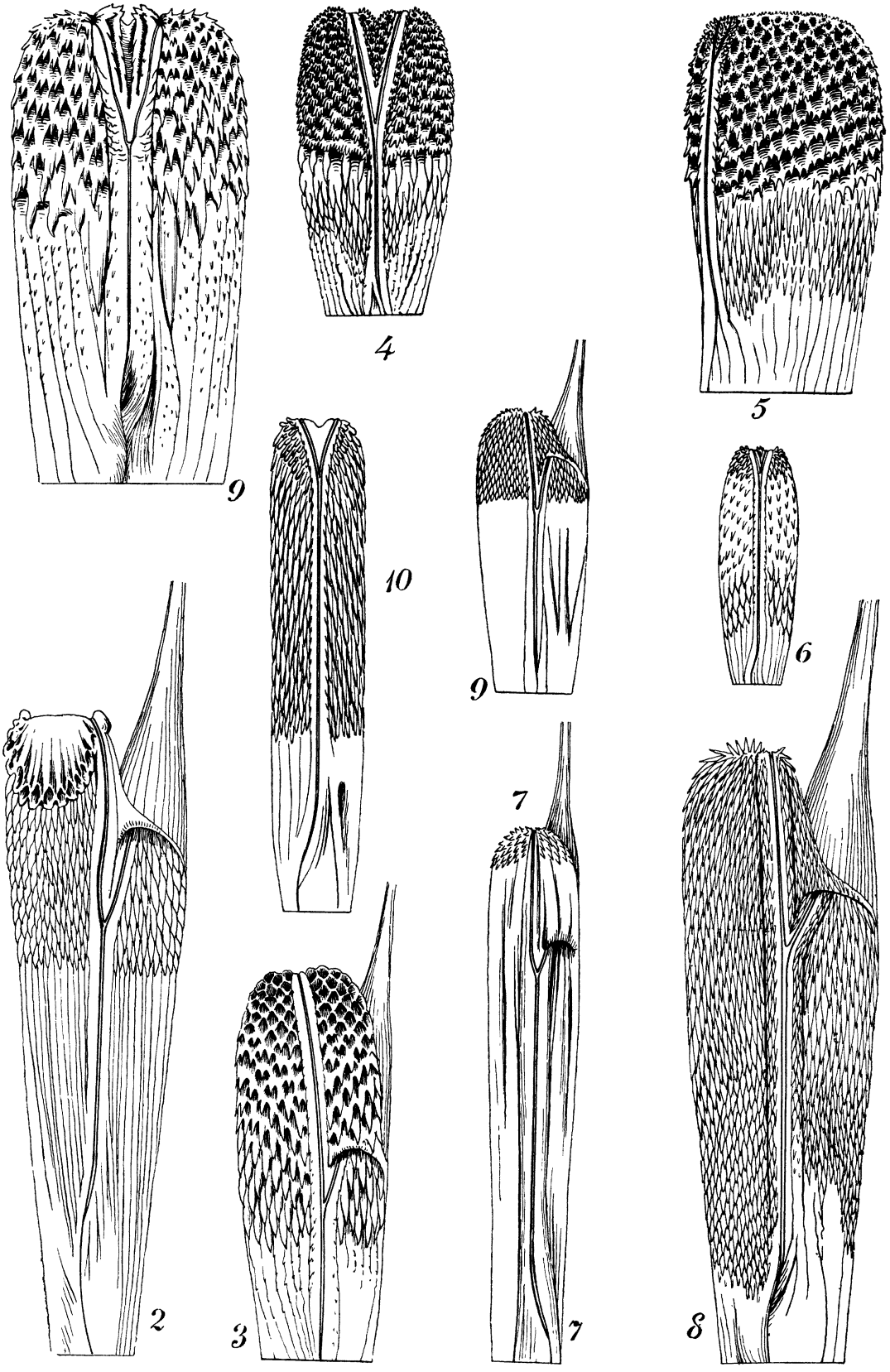
Erythrolamprinæ. Scytalinæ.



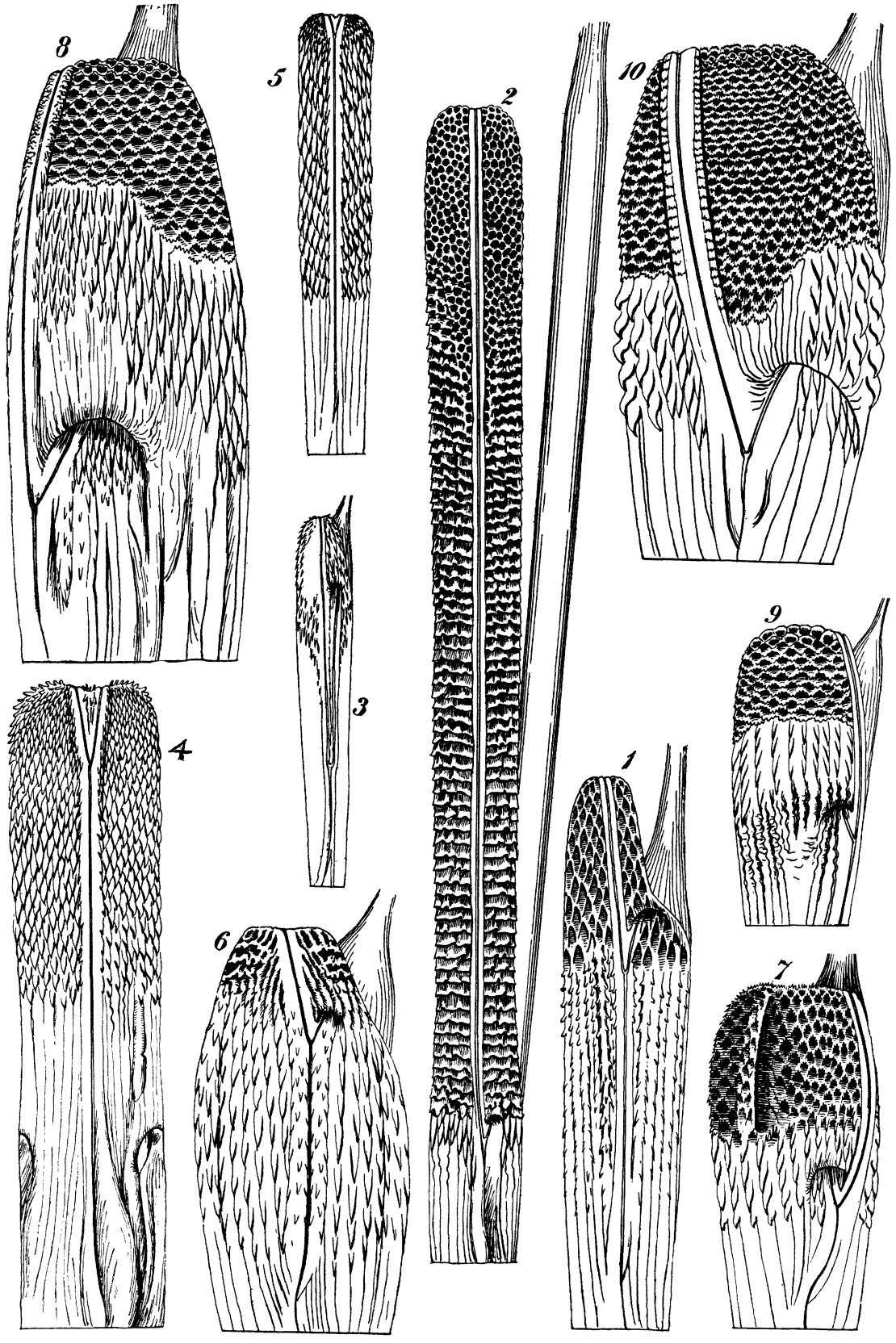
Dromicinæ. Leptognathinæ. Dipsadinæ. Erythrolamprinæ.



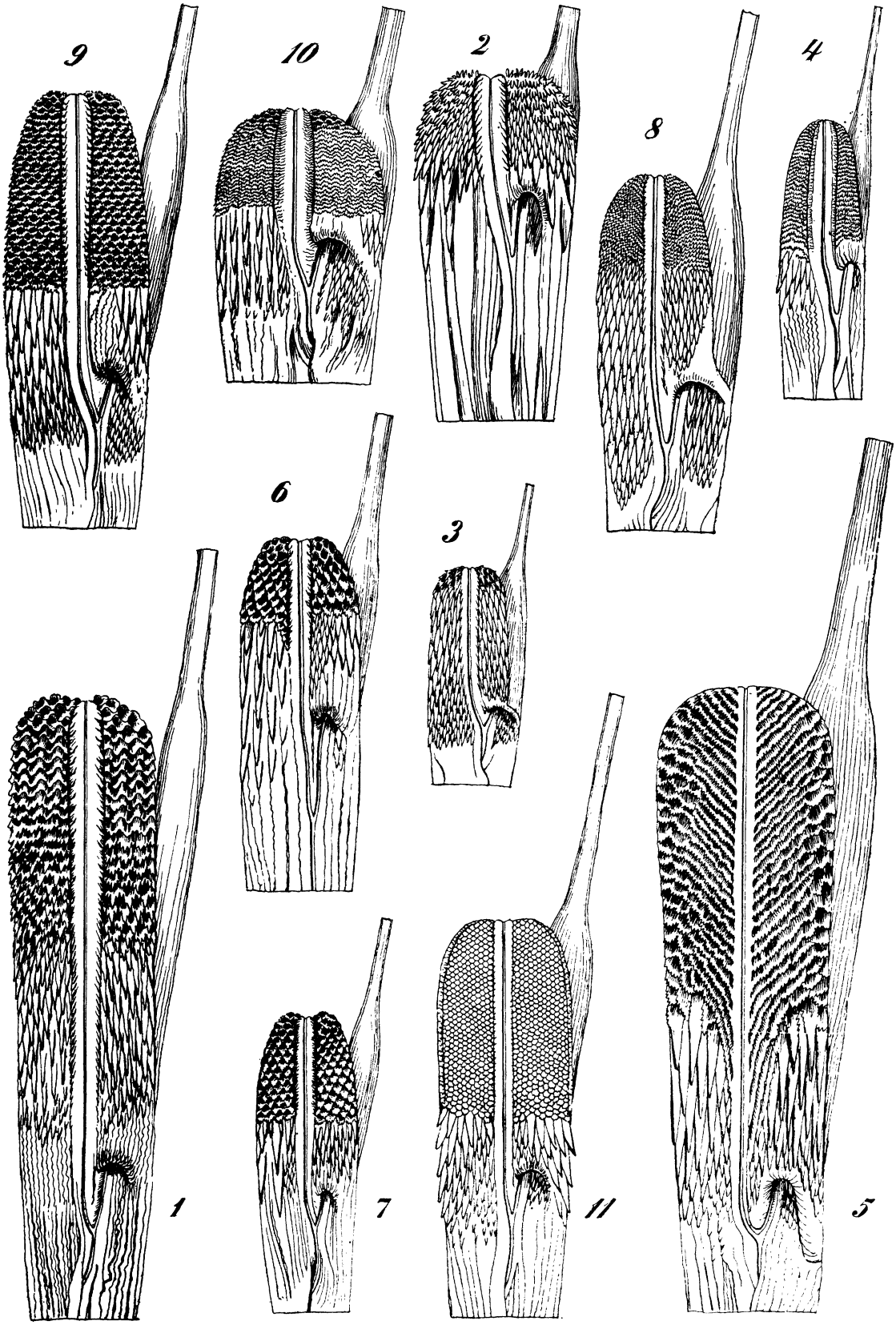
Dipsadinæ.



Proteroglypha. Platycerca.



Proteroglypha. Platycerca. Solenoglypha.



Solenoglypha.